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Washington, D. C.

September 1964

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TABLE OF CONTENTS

SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation 301
- 1. Radiation Surveillance Network, March 1964, PHS 301
- 2. National Air Sampling Network, First Quarter 1964, PHS 305
- 3. Canadian Air Monitoring Program, March 1964 308
- 4. Mexican Air Monitoring Program, March 1964 309
- 5. Pan American Air Sampling Program, March 1964, PAHO and PHS 310
- 6. Gross Beta Activity in Air, North America, March 1964 311

Fission Product Gamma Activity in Air—80th Meridian Network, January and February 1964, AEC 312

SECTION II.—MILK AND FOOD

Milk Surveillance 315
- 1. Pasteurized Milk Network, March 1964, PHS 315
- 2. Indiana Milk Network, March 1964 321
- 3. New York Milk Network, January 1964 321
- 4. Pennsylvania Milk Network, December 1963—March 1964 322
- 5. Radiostrontium in Milk, October—December 1963, AEC 323
- 6. Canadian Milk Network, March 1964 324

Moving Annual Average Radionuclide Concentrations in Pasteurized Milk April 1963—March 1964, PHS 327

Radionuclides in Institutional Diet Samples, October—December 1963, PHS 329

Strontium-90 and Calcium in Infant Diets, 1963, J. Rivera 335

SECTION III.—WATER

Radioactivity in Surface Waters of the United States, January 1964, PHS 337

SECTION IV.—OTHER DATA

Medical X-Ray Units in the City of Baltimore: Findings of the 1963 Pilot Survey, Perry F. Prather, Robert E. Farber and Howard E. Chaney 341

Environmental Levels of Radioactivity at Atomic Energy Commission Installations 345
- 1. Oak Ridge Area, 1963 345
- 2. Paducah Plant, 1963 348
- 3. Portsmouth Area Gaseous Diffusion Plant, 1963 349

Reported Nuclear Detonations, June 1964 350

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

2

Section I—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess human radiation exposure from fallout, it is widely used as the basis of alerting systems for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form and are also shown by beta concentration isograms in figure 6.

1. Radiation Surveillance Network, March 1964

Division of Radiological Health,
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health, which gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The alerting function of the Network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to eliminate interference from naturally-occurring radon daughters. The Network station operators regularly report their field estimates to the Radiation Surveillance Center, Division of Radiological Health, Washington, D. C. When unusually high air levels are reported, appropriate Federal and State officials are notified. These field estimates are reported elsewhere on a monthly basis (*1*).

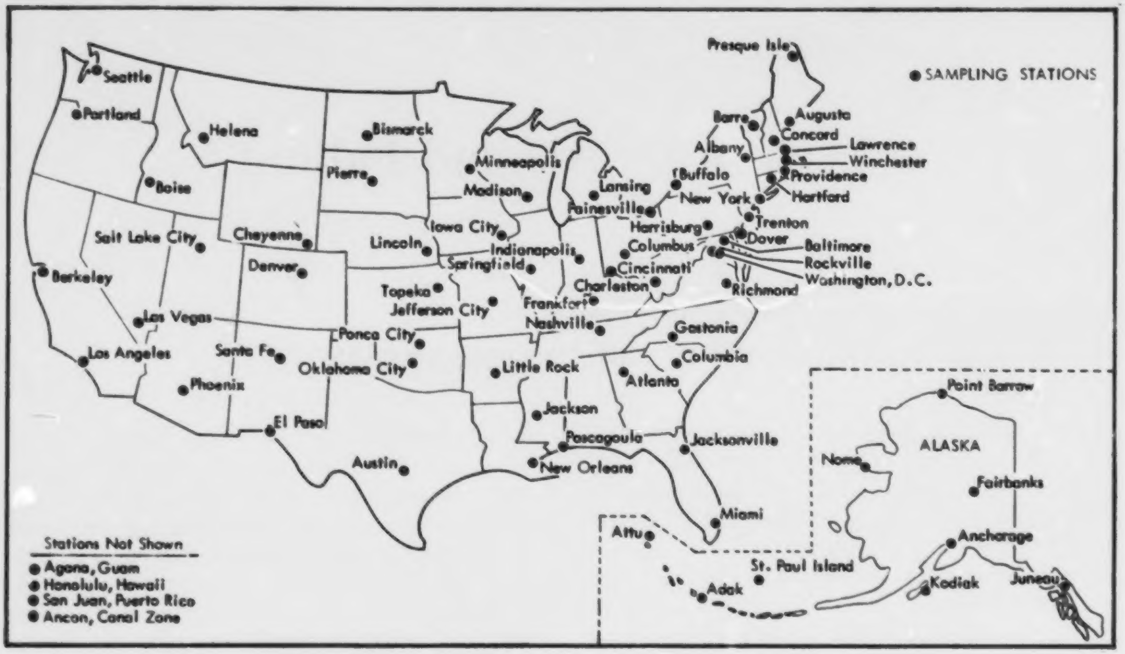
Air

Airborne particulates are collected continuously on a carbon-loaded cellulose dust filter 4 inches in diameter. A volume of about 1800 cubic meters of air is drawn through the filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, and the gross beta activity is measured, using a thin-window, gas-flow proportional counter, calibrated with a 38,700-pc Sr^{90}–Y^{90} Standard.[1] Each filter is counted at least 3 days after the end of the sampling period and again 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. By using the two counts and the Way-Wigner formula (*2*), the age of fission

---

[1] The Sr^{90}–Y^{90} source currently used as a standard was used from April 1962 to August 1963 as 40,000 pc total activity. Beginning with September 1963 data, the nominal activity of the standard was adjusted for decay (about 2½ percent per year) to 38,700 pc.


SAMPLING STATIONS
Seattle
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Salt Lake City
Cheyenne
Lincoln
Iowa City
Berkeley
Denver
Springfield
Indianapolis
Topeka
Jefferson City
Las Vegas
Ponca City
Los Angeles
Santa Fe
Oklahoma City
Phoenix
El Paso
Austin
Presque Isle
Barre
Augusta
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Winchester
Providence
Buffalo
Lansing
New York
Hartford
Painesville
Harrisburg
Trenton
Columbus
Dover
Baltimore
Rockville
Washington, D.C.
Cincinnati
Charleston
Richmond
Frankfort
Nashville
Gastonia
Columbia
Little Rock
Atlanta
Jackson
Pascagoula
Jacksonville
New Orleans
Miami
Point Barrow
ALASKA
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, MARCH 1964

products is estimated[2] and the activity extrapolated to the time of collection.[3] The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*1*).

The Network's highest activity during March was observed on the Las Vegas, Nevada, March 14 sample, (473 pc/m^3, with an estimated age of one day). The twenty samples with the highest activities during March are listed in table 1, which gives the gross beta concentration and estimated age for each.

The March 1964 average gross beta concentration in air for each station is given in table 2. The Network average for March (1.60 pc/m^3) was approximately 50 percent higher than the February average (1.09 pc/m^3). About half of this increase may be attributed to the five samples shown in table 1 with ages less than 100 days, which are evidently associated with the reported venting at the Nevada Test Site, March 13, 1964. The remaining part of the increase appears to be associated with the expected rise of old fission products during the spring months.

Time profiles of gross beta activity in air for eight RSN stations are shown in figure 2.

TABLE 1.—GROSS BETA ACTIVITY AND AGE OF THE TWENTY INDIVIDUAL RSN AIR FILTERS HAVING HIGHEST ACTIVITIES DURING MARCH 1964

Station		Date March	Concentration (pc/m^3)	Age (days)
Calif:	Los Angeles	17	4.08	24
		18	3.80	>100
Fla:	Jacksonville	11	4.30	>100
		31	4.01	>100
	Miami	2	5.21	>100
Nev:	Las Vegas	14	473	1
		15	4.43	40
		16	16.0	5
		18	4.62	>100
		19	4.44	79
		21	4.16	>100
		27	3.81	>100
Ore:	Portland	31	3.86	>100
P. R:	San Juan	6	4.10	>100
R. I:	Providence	17	4.06	>100
Tex:	Austin	1	5.07	>100
		13	4.24	>100
		20	4.25	>100
	El Paso	22	4.27	>100
		26	4.69	>100

---

[2] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value and cannot be used for estimating date of formation.

[3] The Way-Wigner formula is: $AT^{1.2}=C$, where A is the activity, T is the time (in any time unit) after fission product formation, and C is a constant equal to the activity at $T=1$.

TABLE 2.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, MARCH 1964

Station location		Air					Precipitation	
		Number of samples	Concentration (pc/m³)			Last profile in *RHD*	Average concentration [b] (pc/liter)	Total deposition (nc/m²)
			Maximum	Minimum	Average [a]			
Ala:	Montgomery	21	3.63	0.47	1.68		380	[illegible]1,800
Alaska:	Adak	28	1.33	<0.10	0.40	Nov 1963		
	Anchorage	26	1.90	0.37	1.22	Jul 1964	480	5,000
	Attu	26	1.21	<0.10	0.54	Dec 1963		
	Fairbanks	21	1.61	0.52	1.03	Aug 1963	380	2,100
	Juneau	27	3.34	<0.10	1.01	Sep 1963	280	30,900
	Kodiak	9	1.64	<0.10	0.69	Oct 1963		
	Nome	17	1.44	0.18	0.65	Feb 1964		
	Point Barrow Island	31	1.16	0.11	0.67	Jan 1964		
	St. Paul Island	12	1.10	0.17	0.51	Mar 1964		
Ariz:	Phoenix	30	3.33	0.57	2.00	Sep 1963		
Ark:	Little Rock	29	3.37	0.38	1.70	Sep 1963	220	48,500
Calif:	Berkeley	22	3.24	0.17	1.01	Oct 1963	240	11,300
	Los Angeles	22	4.08	0.57	1.89	Feb 1964	260	4,100
Canal Zone:	Ancon	16	1.62	<0.10	0.73	Apr 1964		
Colo:	Denver	29	3.38	0.85	1.75	Nov 1963	300	1,700
Conn:	Hartford	31	2.69	0.37	1.27	Oct 1963	490	34,000
Del:	Dover	19	2.71	0.77	1.61	Aug 1963		
D. C:	Washington	31	3.21	0.29	1.65	Apr 1964	520	27,400
Fla:	Jacksonville	26	4.30	0.69	2.03	Oct 1963	420	15,900
	Miami	30	5.21	0.65	2.10	Feb 1964	420	8,500
Ga:	Atlanta	1	1.00	1.00	1.00	Jul 1964	260	28,100
Guam:	Agana	31	2.85	0.38	1.20	Apr 1964		
Hawaii:	Honolulu	31	2.59	0.13	0.87	Feb 1964	270	29,900
Idaho:	Boise	30	2.27	0.42	1.00	Dec 1963	[d]—	—
Ill:	Springfield	31	1.90	0.21	1.13	Mar 1964	440	1,100
Ind:	Indianapolis	31	2.93	0.37	1.43	Jul 1964	560	120,300
Iowa:	Iowa City	28	2.46	0.39	1.29	Jan 1964	570	31,400
Kans:	Topeka	28	2.65	0.31	1.48	Jul 1964	1,000	46,300
Ky:	Frankfort	24	2.42	0.40	1.58	Feb 1964	740	46,200
La:	New Orleans	31	3.33	0.28	1.46	Mar 1964	270	42,400
Maine:	Augusta	31	2.76	0.42	1.63	Mar 1964	810	81,400
	Presque Isle	27	2.04	0.27	1.08	Nov 1963	—	—
Md:	Baltimore	20	2.37	<0.10	1.38	Nov 1963	670	27,000
	Rockville	9	2.24	0.94	1.75	Mar 1964		
Mass:	Lawrence	30	2.57	0.38	1.45	Aug 1963	1,000	73,200
	Winchester	29	2.87	0.27	1.26	Apr 1964	1,100	88,000
Mich:	Lansing	31	2.57	0.55	1.78	Feb 1964	740	48,100
Minn:	Minneapolis	31	1.93	0.50	1.17	Mar 1964	640	21,800
Miss:	Jackson	29	3.74	0.17	1.92	Apr 1964	300	60,900
	Pascagoula	0				Dec 1963		
Mo:	Jefferson City	31	2.44	0.19	1.21	Jul 1964	470	39,200
Mont:	Helena	31	2.25	0.29	0.96	Nov 1963	740	9,600
Nebr:	Lincoln	13	7.14	<0.10	1.29	Apr 1964	—	—
Nev:	Las Vegas	27	473	0.85	18.7	Jul 1963	—	—
N. H:	Concord	22	3.33	0.28	1.90	Feb 1964		
N. J:	Trenton	31	2.62	0.39	1.33	Apr 1964	730	7,300
N. Mex:	Santa Fe	30	3.37	1.04	2.04	Dec 1963	740	16,500
N. Y:	Albany	22	2.05	0.44	1.09	Jul 1964	420	25,300
	Buffalo	29	1.98	0.30	1.29	Nov 1963	—	—
	New York	27	2.14	0.45	1.36	Dec 1963		
N. C:	Gastonia	30	3.45	0.28	1.76	Jan 1964	290	34,200
N. Dak:	Bismarck	30	1.77	0.68	1.23	Feb 1964	650	5,000
Ohio:	Cincinnati	21	1.96	0.12	1.36	Aug 1963		
	Columbus	30	2.33	<0.10	1.52	Apr 1964	390	85,100
	Painesville	31	3.03	0.64	1.94	Oct 1963	910	91,300
Okla:	Oklahoma	27	2.60	0.48	1.41	Apr 1964	440	11,000
	Ponca City	30	2.25	0.24	1.00	Oct 1963	350	8,300
Ore:	Portland	29	3.86	<0.10	1.43	Oct 1963	270	16,100
Pa:	Harrisburg	28	2.13	0.28	0.86	Jul 1964	360	9,700
P. R:	San Juan	25	4.10	0.48	1.37	Mar 1964	270	8,700
R. I:	Providence	28	4.06	0.36	1.59	Jan 1964	600	9,700
S. C:	Columbia	30	2.69	0.25	1.45	Dec 1963	400	68,500
S. Dak:	Pierre	28	1.83	0.47	1.09	Sep 1963	700	2,700
Tenn:	Nashville	30	3.16	0.66	1.79	Jan 1964	510	43,900
Tex:	Austin	30	5.07	0.74	2.39	Aug 1963	340	12,200
	El Paso	31	4.69	0.68	2.06	Jan 1964	720	16,000
Utah:	Salt Lake City	29	2.48	0.65	1.45	Aug 1963	450	27,700
Vt:	Barre	30	3.33	0.45	1.84	Sep 1963	400	42,300
Va:	Richmond	30	2.10	0.26	1.17	Sep 1963	310	15,100
Wash:	Seattle	31	1.52	<0.10	0.50	Jul 1964	330	20,500
W. Va:	Charleston	31	3.04	0.62	1.48	Dec 1963	1,400	119,000
Wisc:	Madison	30	2.56	0.65	1.64	Sep 1963	740	42,000
Wyo:	Cheyenne	29	3.03	0.68	1.45	Aug 1963	940	9,500
Network summary		1,947	473	<0.10	1.60			

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[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed before the average.

[b] The minimum concentration reported for a single sample is 200 pc/liter.

[c] Profile scheduled for August 1964.

[d] Dash indicates no evaporated sample received.

5

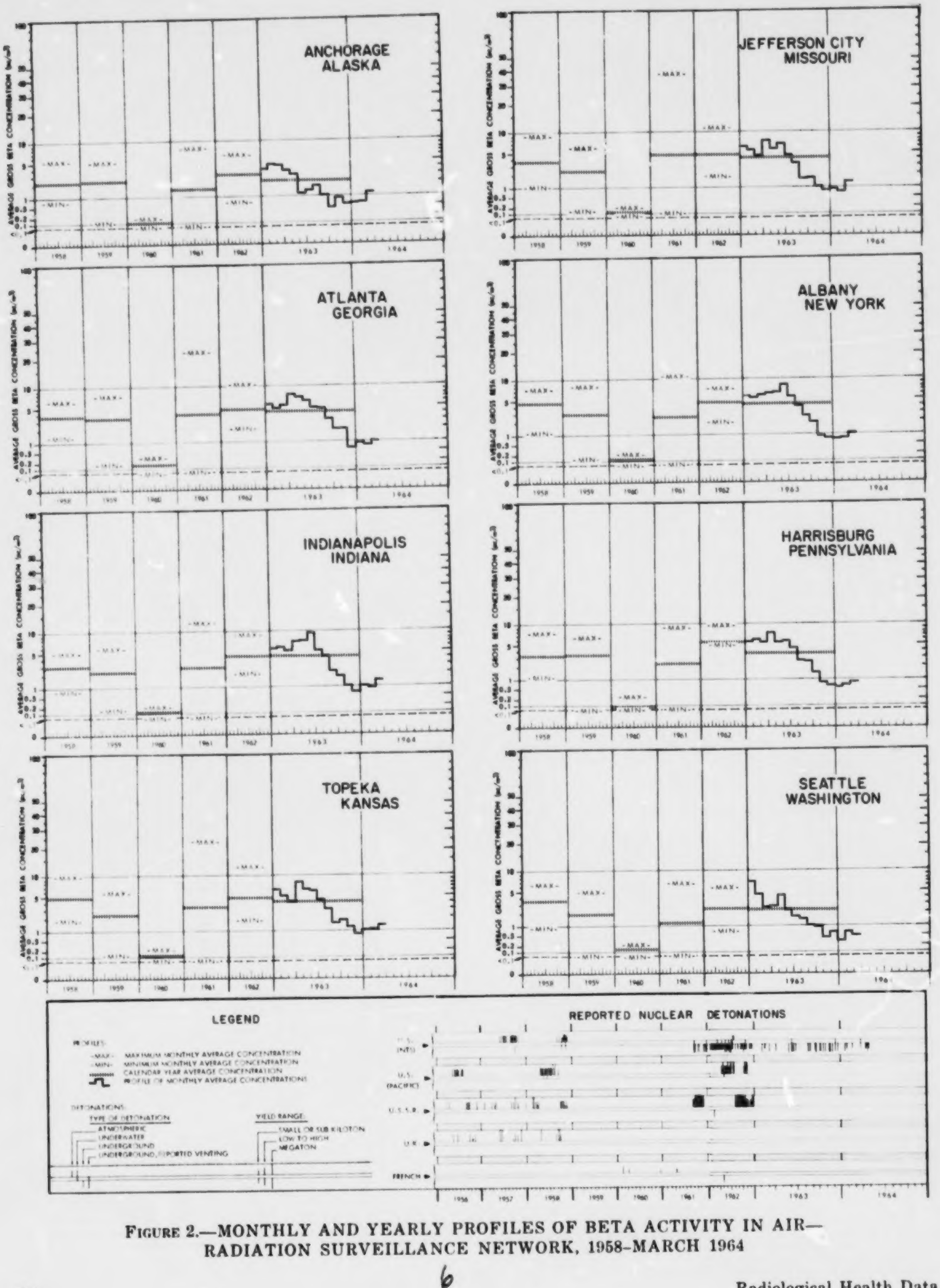

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR—RADIATION SURVEILLANCE NETWORK, 1958–MARCH 1964

6

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation of time of collection. Deposition for the sample is determined by:

$$D=\frac{CP}{1000}$$

where D is the deposition in nc/m^2, C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, $\bar{C}$, is determined by:

$$\bar{C}=\frac{\Sigma D}{\Sigma P}\times 1000$$

The March 1964 average concentrations and total depositions are given in table 2.

2. National Air Sampling Network First Quarter 1964

Division of Air Pollution,
Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. The NASN analyzes air samples for the total quantity of suspended particulate matter, benzene-soluble organic matter, and gross beta radioactivity. Selected samples are also analyzed for nitrates, sulfates, and a number of metals. These analyses aid in the detection of trends in levels of pollution with respect to time, location, population density, climate, and other factors associated with air quality.

Gross Beta Activity in Air

NASN stations (see figure 3) are manned by cooperating Federal, State, and local agencies. The current basic network consists of 110 sampling stations which operate every year in 73 large cities and 37 nonurban areas. In addition, there are stations in 130 cities which operate every other year. Thus, there are 240 sampling stations in all in the NASN network, of which 175 are active in any given year.

Continuous 24-hour samples of suspended particulate matter are taken at each station. The samples, representing approximately 2,000 cubic meters of air, are collected on glass fiber filters on a biweekly random sampling schedule. They are then sent for analysis to the Network laboratory at the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio. First quarter 1964 data appear in table 3.

Gross Beta Activity in Precipitation

The present reporting of gross beta activity in precipitation originated in 1959 when a precipitation collection and analysis program was established by the Weather Bureau Research Station in Cincinnati, Ohio, and the National Air Sampling Network. Monthly composite samples of precipitation are collected at 29 stations, which are located at Weather Bureau offices or airports. They are then forwarded to the Network laboratory for analysis.

The laboratory analyzes these samples for total solids and for a large number of metals and nonmetals. In addition, each sample is analyzed for fission product gross beta radioactivity if a sufficient volume of precipitation remains after chemical analyses have been made. Precipitation data for the first quarter 1964 are presented in table 4.

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NASN, FIRST QUARTER, 1964

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average
Ala:	Birmingham	7	2.[illegible]	0.8	1.8
	Gadsden	7	2.5	0.6	1.6
	Mobile	7	3.8	0.3	2.2
Alaska:	Anchorage	6	1.9	0.5	1.1
Ariz:	Grand Canyon Pk.[a]	6	3.7	1.4	2.4
	Maricopa Co.[a]	7	5.5	2.5	3.7
	Phoenix	7	4.7	2.0	3.0
	Tucson	6	2.7	0.6	1.9
Ark:	Little Rock	7	2.4	0.8	1.5
	Montgomery Co.[a]	4	2.9	0.9	2.0
	Texarkana	5	2.9	0.8	1.7
Calif:	Bakersfield	7	2.8	1.0	1.7
	Burbank	6	3.7	1.8	2.4
	Humboldt Co.[a]	5	3.0	0.2	1.1
	Los Angeles	6	3.8	0.7	2.1
	Monterey	7	3.6	1.1	1.8
	Oakland	6	2.6	0.7	1.6
	Pasadena	6	3.2	1.5	2.0
	Sacramento	7	3.5	0.8	1.6
	San Diego	6	3.5	1.8	2.4
	San Francisco	7	3.3	0.5	1.6
	Santa Ana	6	3.2	1.2	1.9
	Santa Barbara	7	4.0	0.6	2.1
Colo:	Denver	7	3.3	1.1	2.1
	Montezuma Co.[a]	7	4.9	1.6	2.8
Conn:	Hartford	6	2.5	0.6	1.5
	New Haven	6	2.2	0.9	1.5
Del:	Kent Co.[a]	5	2.5	0.5	1.2
	Wilmington	[illegible]	2.7	0.6	1.4
D. C:	Washington	5	2.6	1.2	1.9
Fla:	Florida Keys[a]	5	3.7	0.6	2.2
	Jacksonville	7	3.3	0.2	1.7
	Orlando	5	4.1	1.6	2.8
	Tampa	6	5.7	1.2	2.7
Ga:	Atlanta	7	3.3	0.6	1.8
Hawaii:	Honolulu	6	2.2	0.2	1.2
Idaho:	Boise	7	3.1	0.5	1.5
	Butte Co.[a]	7	2.2	0.6	1.5
Ill:	Chicago	5	2.4	1.0	1.7
	Cicero	6	2.9	0.9	1.6
	Moline	5	3.4	1.0	1.7
	Peoria	6	1.9	1.0	1.4
	Rock Island	6	3.8	0.9	2.0
Ind:	East Chicago	5	1.9	0.9	1.3
	Evansville	5	3.6	0.7	1.9
	Fort Wayne	6	2.5	0.6	1.7
	Gary	6	3.1	0.9	1.9
	Indianapolis	6	2.1	1.1	1.6
	Lafayette	5	2.5	0.8	1.6
	Parke Co.[a]	7	2.2	0.7	1.4
Iowa:	Davenport	3	1.9	1.4	1.7
	Delaware Co.[a]	5	1.6	0.4	1.1
	Des Moines	6	3.6	0.8	1.7
	Dubuque	7	2.8	1.1	1.6
Kans:	Kansas City	7	3.3	0.7	1.6
	Wichita	6	3.8	0.9	2.2
Ky:	Ashland	6	3.6	1.0	1.9
	Covington	5	2.7	1.1	1.9
	Louisville	5	2.3	1.1	1.7
	Newport	4	3.4	1.2	2.1
La:	Baton Rouge	7	4.0	0.7	1.8
	Lake Charles	7	2.9	0.8	1.4
	New Orleans	7	4.2	0.8	2.0
Maine:	Acadia Nat'l. Pk.[a]	6	3.9	0.9	2.2
	Portland	6	2.7	0.8	1.7
Md:	Baltimore	5	2.2	0.6	1.4
	Calvert Co.[a]	7	3.2	0.8	1.8
Mass:	Boston	6	4.4	1.4	2.2
	Springfield	7	2.8	0.7	1.8
Mich:	Detroit	7	1.9	0.5	1.3
	Wyandotte	5	1.8	1.1	1.4
Minn:	Duluth	6	2.0	0.9	1.4
	Minneapolis	7	1.9	0.4	1.2
	Moorhead	6	2.0	0.8	1.4
	St. Paul	7	2.6	0.5	1.6
Miss:	Jackson	7	3.2	0.4	1.7
Mo:	Kansas City	7	4.2	0.7	2.1
	Shannon Co.[a]	7	3.1	1.5	2.3
	St. Louis	7	2.7	0.8	1.5
Mont:	Glacier Nat'l. Pk.[a]	7	1.8	0.5	0.9
	Helena	7	1.7	0.8	1.2
Nebr:	Omaha	7	4.1	1.4	2.2
	Thomas Co.[a]	6	3.4	0.6	2.0
Nev:	Las Vegas	6	3.8	1.6	2.5
	White Pine Co.[a]	6	3.0	0.5	2.0
N. H:	Concord	5	2.9	0.6	1.7
	Coos Co.[a]	7	2.5	0.3	1.4
N. J:	Camden	7	3.0	0.7	1.7
	Clinton	5	2.3	0.8	1.7
	Marlton	3	2.6	1.7	2.2
	Newark	7	2.6	0.9	1.7
	New Brunswick	6	2.6	0.8	1.9
	Princeton	3	2.3	1.8	2.1
	Trenton	6	2.1	0.8	1.5
	Glassboro	5	2.4	1.5	1.9
N. M:	Albuquerque	7	4.0	1.5	2.6
	Rio Arriba Co.[a]	7	4.9	0.9	2.8
N. Y:	Cape Vincent[a]	7	2.6	0.5	1.5
	New York	7	2.3	0.8	1.4
N. C:	Cape Hatteras	7	3.0	1.4	2.3
	Charlotte	6	2.7	0.9	1.6
	Fayetteville	5	2.8	1.0	1.9
	Winston-Salem	7	3.0	0.6	1.8
N. Dak:	Bismarck	7	2.2	0.6	1.3
	Fargo	6	1.8	0.6	1.3
	Ward Co.[a]	5	4.1	0.6	1.8
Ohio:	Akron	6	2.6	1.0	1.6
	Cincinnati	7	3.4	0.9	2.1
	Cleveland	7	2.3	0.7	1.4
	Columbus	7	2.6	1.1	1.8
	Dayton	7	2.8	1.1	1.7
	Lorain	6	2.3	1.1	1.8
	Stuebenville	5	2.7	1.7	2.1
	Toledo	7	2.3	0.5	1.6
	Youngstown	7	2.4	1.1	1.8
Okla:	Cherokee Co.[a]	6	3.6	0.6	1.6
	Oklahoma City	7	3.6	1.4	2.3
	Tulsa	7	2.8	0.6	1.7
Ore:	Portland	6	2.0	0.2	0.9
Pa:	Clarion Co.[a]	5	2.2	1.5	1.8
	Lancaster	4	2.6	1.3	1.9
	Philadelphia	7	2.7	1.0	1.8
	Pittsburgh	7	2.9	1.1	1.9
P. R:	Guayanilla	7	3.3	0.8	1.9
	Ponce	7	3.2	0.7	1.8
	San Juan	6	3.2	0.7	1.9
R. I:	Providence	5	2.5	0.6	1.6
	Washington Co.[a]	6	2.9	1.0	1.8
S. C:	Columbia	7	2.6	1.0	1.6
	Richland Co.[a]	7	2.9	1.0	1.6
S. Dak:	Black Hills	6	3.9	1.1	2.2
	Sioux Falls[a]	6	2.5	0.8	1.3
Tenn:	Chattanooga	7	3.0	0.6	1.5
	Memphis	5	2.9	1.0	2.0
	Nashville	7	3.5	0.3	1.7
Tex:	Aransas Co.[a]	7	2.7	1.4	2.0
	Dallas	7	3.0	0.5	1.9
	El Paso	7	8.3	1.2	4.3
	Houston	5	1.9	0.9	1.4
	San Antonio	6	3.2	0.8	2.0
	Texarkana	5	3.8	0.8	1.9
	Waco	7	3.9	1.0	2.1
Utah:	Ogden	7	2.5	1.1	1.9
	Salt Lake City	7	2.6	1.3	2.0
Vt:	Burlington	6	2.6	0.5	1.5
	Orange Co.[a]	7	2.9	0.4	1.4
Va:	Danville	6	3.1	0.6	2.0
	Norfolk	7	3.2	1.4	2.2
	Shenandoah Pk.[a]	7	3.1	0.8	1.8
Wash:	Seattle	7	1.7	0.3	0.7
	Tacoma	6	1.9	0.3	0.9
W. Va:	Charleston	7	2.6	0.7	1.8
	Huntington	6	2.6	0.9	2.0
	Parkersburg	7	2.5	0.9	1.7
Wis:	Door Co.	6	2.4	1.0	1.6
	Eau Claire[a]	6	2.0	0.9	1.3
	Milwaukee	7	3.5	0.7	1.6
	Racine	7	2.7	0.8	1.4
	Superior	5	1.6	1.0	1.4
Wyo:	Cheyenne	6	4.0	0.8	2.2
	Yellowstone Pk.[a]	7	2.4	0.6	1.3
Network summary		1,025	5.7	0.2	1.78

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[a] Nonurban stations.

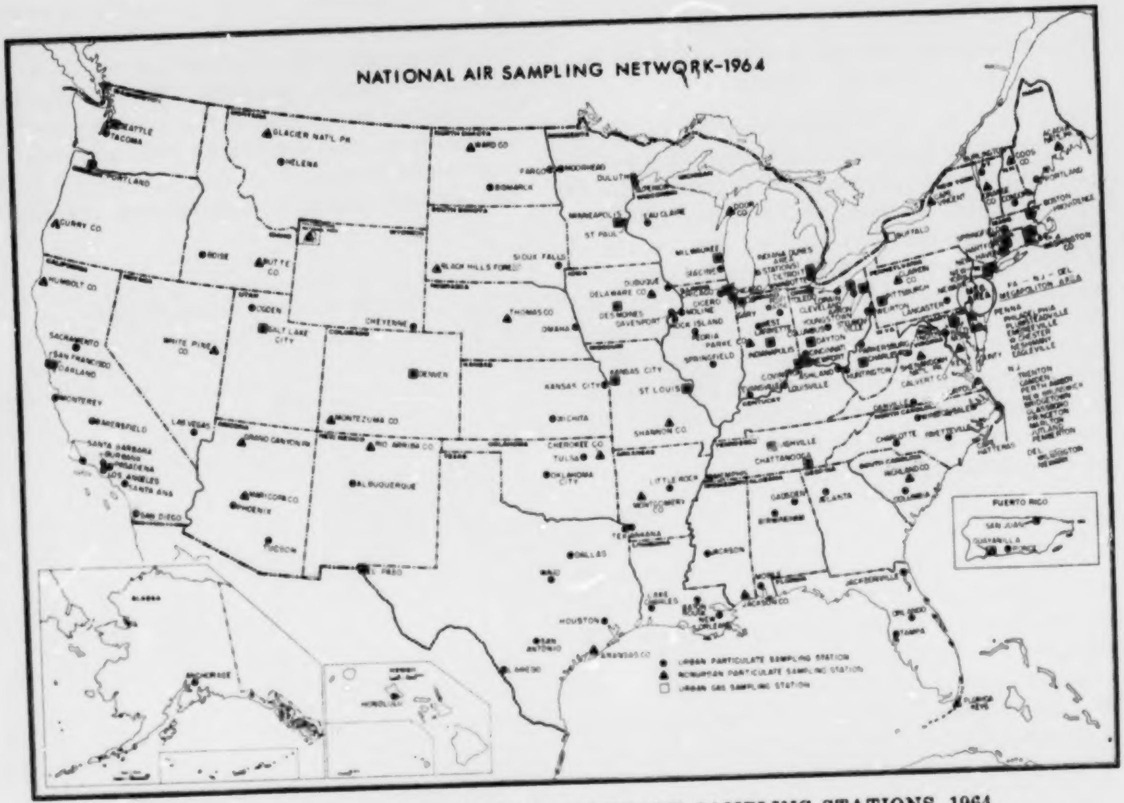
NATIONAL AIR SAMPLING NETWORK-1964
● URBAN PARTICULATE SAMPLING STATION
▲ NONURBAN PARTICULATE SAMPLING STATION
□ URBAN GAS SAMPLING STATION
PUERTO RICO
SAN JUAN
SEATTLE
TACOMA
PORTLAND
GLACIER NAT'L PK
HELENA
BOISE
SACRAMENTO
SAN FRANCISCO
OAKLAND
LOS ANGELES
SAN DIEGO
PHOENIX
TUCSON
ALBUQUERQUE
DENVER
CHEYENNE
SALT LAKE CITY
KANSAS CITY
ST LOUIS
OMAHA
DES MOINES
WICHITA
TULSA
OKLAHOMA CITY
DALLAS
HOUSTON
SAN ANTONIO
EL PASO
LITTLE ROCK
CHATTANOOGA
ATLANTA
JACKSONVILLE
TAMPA
NEW ORLEANS
LAKE CHARLES
LOUISVILLE
CLEVELAND
BUFFALO
BOSTON
PORTLAND
PROVIDENCE
HATTERAS
ALASKA
ANCHORAGE
HONOLULU

FIGURE 3.—NATIONAL AIR SAMPLING NETWORK SAMPLING STATIONS, 1964

TABLE 4.—GROSS BETA ACTIVITY IN PRECIPITATION, NASN, FIRST QUARTER 1964

Station		January		February		March	
		pc/liter	nc/m³	pc/liter	nc/m³	pc/liter	nc/m³
Ala:	Montgomery	120	18	600	38	370	36
Calif:	Santa Maria	—	—	—	—	215	8
Fla:	Tampa	120	15	220	15	490	23
Ill:	Chicago (O'Hare)	—	—	—	—	1,520	11
La:	Lake Charles	120	12	290	18	500	43
Maine:	Caribou	—	—	—	—	450	26
Mass:	Nantucket	230	17	550	50	1,450	58
Mich:	Sault Ste Marie	340	22	580	24	—	—
Minn:	St. Cloud	—	—	—	—	500	20
Mo:	Columbia	—	—	—	—	650	29
N. Y:	Albany	430	26	—	—	570	41
N. C:	Hatteras	80	12	260	36	—	
Ohio:	Cincinnati (Airport)	320	17	—	—	280	77
	Cincinnati (Gest St.)	270	19	—	—	320	57
Pa:	Philadelphia	480	40	620	54	—	—
S. C:	Charleston	170	27	200	30	520	49
	Greenville	200	28	215	26	240	41
Tenn:	Nashville	100	4	500	32	330	29
Va:	Sterling	210	16	620	47	520	29
Wash:	Tatoosh	340	71	450	39	580	[illegible]

9

3. Canadian Air Monitoring Program,[4] March 1964

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program, the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation. Twenty-four collection stations are located at airports (see figure 4), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in previous reports of the Department (*3–7*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas flow Geiger-Mueller counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for March 1964 are given in table 5 and presented in conjunction with U. S. and Mexican data by an isogram map (figure 6).

TABLE 5.—GROSS BETA ACTIVITY IN AIR, CANADA, MARCH 1964

[Average concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Calgary	27	3.6	0.2	1.4
Coral Harbour	31	2.6	0.5	1.1
Edmonton	31	2.5	0.4	1.2
Ft. Churchill	29	2.0	0.2	1.1
Ft. William	31	2.5	1.0	1.7
Fredericton	31	2.1	0.1	1.2
Goose Bay	31	2.0	0.3	1.3
Halifax	24	3.1	0.5	1.6
Inuvik	30	2.8	0.9	1.6
Montreal	31	2.5	0.6	1.7
Moosonee	29	2.3	0.9	1.5
Ottawa	29	2.2	0.6	1.5
Quebec	31	2.2	0.5	1.4
Regina	30	2.8	0.5	1.4
Resolute	31	2.4	0.2	1.0
St. John's, Nfld	30	3.0	0.1	1.1
Saskatoon	31	3.1	0.6	1.6
Sault Ste. Marie	31	2.9	0.6	1.7
Toronto	30	0.6	0.1	0.4
Vancouver	31	1.8	0.1	0.7
Whitehorse	31	3.9	0.1	1.6
Windsor	31	2.7	0.4	1.5
Winnipeg	31	2.3	0.7	1.5
Yellowknife	30	2.1	0.9	1.4
Network summary	722	3.9	0.1	1.3

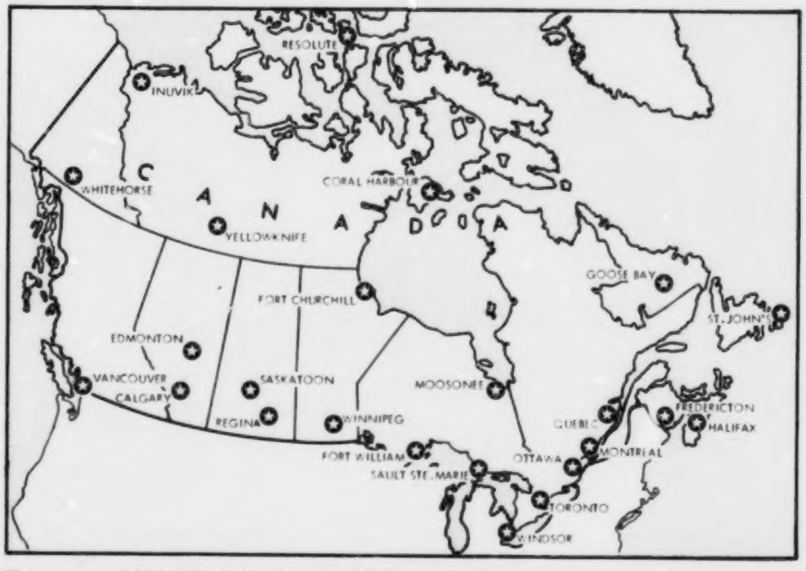

FIGURE 4.—CANADIAN AIR AND PRECIPITATION STATIONS, MARCH 1964

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[4] Data from *Radiation Protection Programs 4*:11–24, Radiation Protection Division, Canadian Department of National Health and Welfare (April 1964).

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450° C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}–Y^{90} source. Gross beta activities for March 1964 samples are given in table 6. Radionuclide analyses appear quarterly.

TABLE 6.—GROSS BETA ACTIVITY IN PRECIPITATION, CANADA, MARCH 1964

Station	Total beta activity	
	pc/liter	nc/m²
Calgary	964	8.1
Coral Harbour	[a]	2.4
Edmonton	750	8.0
Ft. Churchill	347	3.1
Ft. William	660	11.4
Fredericton	403	36.7
Goose Bay	191	21.8
Halifax	161	22.9
Inuvik	582	3.0
Montreal	449	30.8
Moosonee	269	8.9
Ottawa	577	19.3
Quebec	371	41.5
Regina	483	5.6
Resolute	541	4.1
St. John's, Nfld	389	42.0
Saskatoon	485	3.3
Sault Ste. Marie	473	38.8
Toronto	462	41.3
Vancouver	788	76.5
Whitehorse	185	4.7
Windsor	722	58.9
Winnipeg	191	9.6
Yellowknife	777	4.7
Average	488	21.1

[a] Trace precipitation.

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4. Mexican Air Monitoring Program
March 1964

National Commission of Nuclear Energy

As part of its Radiological Protection Program (RPP), the Comisión Nacional de Energía Nuclear (CNEN) established the Radiation Surveillance Network of Mexico to provide a means for determining increased levels of radioactivity in air and precipitation.

The network has been gradually expanded to 17 stations (see figure 5). Twelve of the 17 stations are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí and Ensenada; Staff Members of the RPP operate the station at Mexico City while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Instituto de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week, at the rate of approximately 1,200 cubic meters per day, through a high-efficiency glass fiber filter, 6″ x 8″, using high volume samplers. After each 24-hour period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios Sobre Contaminación Radiactiva", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughters' natural radioactivity. Data are not extrapolated to time of collection.

The maximum, minimum and average fission product beta concentrations in surface air during March 1964 are presented in table 7.

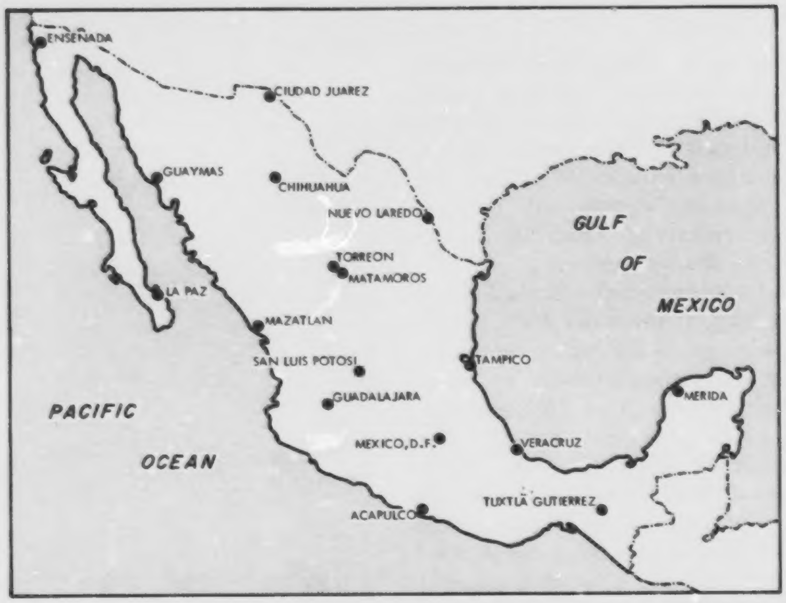

FIGURE 5.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

TABLE 7.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, MARCH 1964

[Concentrations in pc/m^3]

Station	Number of samples	Maximum	Minimum	Average
Acapulco[a]	3	2.1	0.7	—
Ciudad Juárez	27	4.5	0.5	1.5
Chihuahua	17	5.0	0.6	2.4
Ensenada	13	2.8	0.7	1.4
Guadalajara	7	2.0	0.2	0.8
Guaymas[a]	0	—	—	—
La Paz	23	4.1	0.8	2.2
Matamoros[a]	0	—	—	—
Mazatlán	9	3.8	1.0	2.4
Mérida	13	2.3	0.5	1.2
Mexico City	15	1.6	0.1	0.5
Nuevo Laredo	6	2.6	0.5	1.3
San Luis Potosí	8	2.8	0.6	1.3
Tampico	6	1.7	0.3	0.7
Torreón	19	6.9	0.6	2.6
Tuxtla Gutiérrez[a]	0	—	—	—
Veracruz[a]	3	1.8	0.1	—

[a] Temporarily shut down.

5. Pan American Air Sampling Program March 1964

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by three countries in South America under the auspices of a collaborative program developed by the Pan American Health Organization and the Public Health Service (PHS) for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The three air sampling stations included in the program are operated by the technical staff of the Ministry of Health in each country. The station in Santiago, Chile is operated by the Occupational Health Service; in Lima, Peru by the Institute of Occupational Health; and in Caracas, Venezuela by the Venezuelan Institute for Scientific Investigations. The Caracas station began operation in November 1962 and the other two stations were started the following month.

The March 1964 air monitoring results from the three participating countries are given in table 8. The Caracas station is shown on the gross beta concentration isogram map (figure 6) and its March average, 1.0 pc/m^3 (after adjustment by the RSN intercalibration factor[5]) was used in estimating the position of the 1.0 pc/m^3 isogram.

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[5] The RSN factor is 1.28.

TABLE 8.—GROSS BETA ACTIVITY IN AIR, MARCH 1964

[Concentrations in pc/m³]

Sampling stations	No. of samples	Maximum	Minimum	Average [a]
Caracas, Venezuela	23	1.30	<0.10	0.78
Lima, Peru	0	—	—	—
Santiago, Chile	16	0.16	<0.10	<0.10

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

6. Gross Beta Activity in Air, North America, March 1964

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America.[6] The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*8*).

With the formation of the Mexican Air monitoring program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, National Air Sampling Network, the HASL 80th Meridian Network, and the Mexican Network (*9*). The new intercalibration factors include some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963. The intercalibration fac-

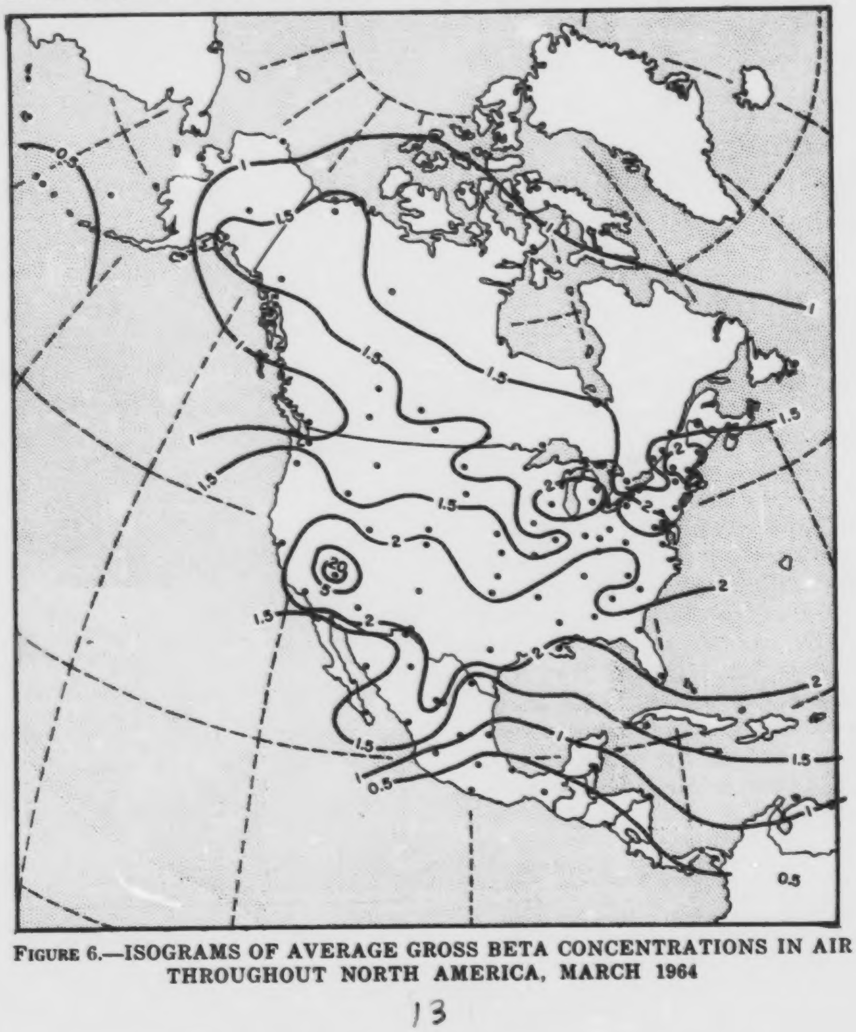

FIGURE 6.—ISOGRAMS OF AVERAGE GROSS BETA CONCENTRATIONS IN AIR THROUGHOUT NORTH AMERICA, MARCH 1964

tors are, therefore, not the same as were previously used.

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[6] The January 1963 through February 1964 isogram maps were published in the May 1963 through June 1964 issues of *Radiological Health Data*.

Figure 6 shows the March 1964 activity in air throughout North America based on the data from the Canadian Air Monitoring Program, the Radiation Surveillance Network and Mexican Air Monitoring program. An intercalibration factor of 1.28 was applied to the RSN data and the Mexican data were multiplied by 0.81 in order to adjust them to Canadian data.

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FISSION PRODUCT GAMMA ACTIVITY IN AIR— 80TH MERIDIAN NETWORK, JANUARY AND FEBRUARY 1964

Health and Safety Laboratory[1]
Atomic Energy Commission

Fourteen air sampling stations near the 80th Meridian (West) from Thule, Greenland, to Punta Arenas, Chile, make up the Health and Safety Laboratory (HASL) 80th Meridian Network (figure 1). An additional station at Mauna Loa, Hawaii, is included for comparing data with that from Chacaltaya, Bolivia; both are at a high elevation and their respective latitudes North and South are nearly equal.

Air particulates are sampled on 8-inch-diameter polystyrene (Microsorban) filters, drawing air through the filters, continuously at a rate of about 1400 cubic meters per day. Filters are changed on the 1st, 8th, 15th, and 22nd of each month and forwarded to HASL for analysis. A total gamma count is made approximately two weeks after the end of the sampling period using an 8 x 4-inch sodium iodide (thallium activated) crystal.

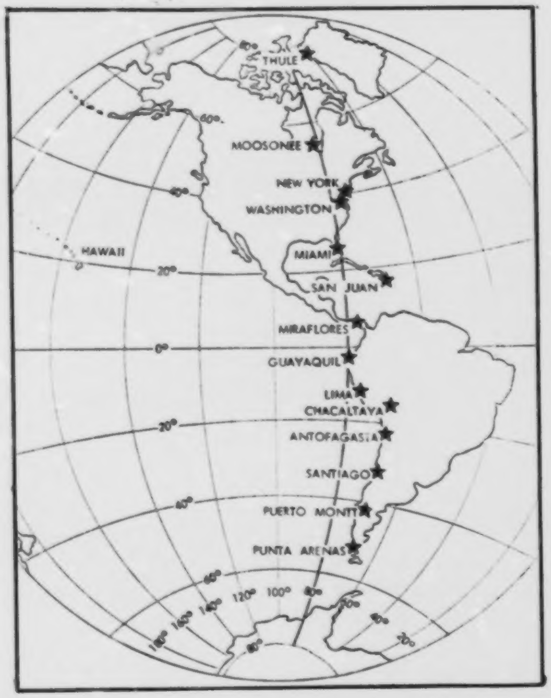

FIGURE 1.—80TH MERIDIAN NETWORK SAMPLING STATIONS

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[1] This report was developed from information and data in the March 1963, January 1964, and February 1964 monthly reports of: W. R. Collins, Jr., *80th Meridian Network, Results of Air Sampling Measurements*, Health and Safety Laboratory, U.S. Atomic Energy Commission, New York, N.Y. 10014.

The results of total gamma activity determinations in weekly ground level air filter samples taken at 80th Meridian stations during January and February 1964 are listed in tables 1 and 2, together with average monthly activity concentrations calculated for each site. The average monthly activities are also plotted in figure 2 as an activity—latitude profile.

The monthly averages for all of the northern sites were 0.77 and 0.85 γ/min/m³ for January and February, respectively. The corresponding averages in the Southern Hemisphere were 0.055 and 0.051 γ/min/m³. These averages are about one-tenth of the averages for January and February 1963.

TABLE 1.—GAMMA ACTIVITY IN SURFACE AIR, 80TH MERIDIAN NETWORK, JANUARY 1964

[Activity in gamma photons/min/m³]

Station latitude, elevation	January sampling periods				January average
	1-7	8-14	15-21	22-31	
Thule, Greenland 77° N, 259 m	0.948	1.00	0.845	0.986	0.948
Moosonee, Canada 51° N, 10 m	0.871	0.689	0.657	0.704	0.728
New York, N. Y. 41° N, 38 m	0.580	0.430		0.421	0.485
Washington, D. C. 39° N, 82 m	0.722	0.481	0.769	0.865	0.728
Miami, Fla. 26° N, 4 m	1.35	0.713	1.36	2.04	1.42
Mauna Loa, Hawaii 19° N, 3394 m	0.416	0.931	0.809	1.08	0.838
San Juan, P. R. 18° N, 10 m	0.312	0.140	0.275	1.82	0.736
Miraflores, Canal Zone 9° N, 10 m	0.310	0.305	0.344	0.477	0.371
Guayaquil, Ecuador 0°-08′ S, 7 m	0.0405	0.0384	0.0437	0.0600	0.0457
Lima, Peru 12° S, 30 m	0.0757	0.0923	0.0814	0.101	0.0876
Chacaltaya, Bolivia 17° S, 5220 m	0.0341	0.0183	0.0472	0.0280	0.0315
Antofagasta, Chile 24° S, 519 m	0.0643	0.0545	0.141	0.0807	0.0848
Santiago, Chile 33° S, 5 m	0.0498	0.0817	0.0950	0.0564	0.0693
Puerto Montt, Chile 41° S, 5 m	0.0473	0.0460	0.0580	0.0279	0.0448
Punta Arenas, Chile 53° S, 3 m	0.0110	0.0255	0.0364	0.0211	0.0235

TABLE 2.—GAMMA ACTIVITY IN SURFACE AIR, 80TH MERIDIAN NETWORK, FEBRUARY 1964

[Activity in gamma photons/min/m³]

Station latitude, elevation	February sampling periods				February average
	1-7	8-14	15-21	22-31	
Thule, Greenland 77° N, 259 m	1.03	0.596	0.732	0.805	0.791
Moosonee, Canada 51° N, 10 m	0.628	0.854	0.380	0.797	0.665
New York, N. Y. 41° N, 38 m	0.550		0.531	1.05	0.710
Washington, D. C. 39° N, 82 m	0.885	0.884	0.706	0.850	0.833
Miami, Fla. 26° N, 4 m	1.49	1.59	1.62	1.32	1.50
Mauna Loa, Hawaii 19° N, 3394 m	1.91	1.08	1.22	1.62	1.48
San Juan, P. R. 18° N, 10 m	0.614	0.0929	0.524	0.495	0.432
Miraflores, Canal Zone 9° N, 10 m	0.598	0.501	0.540	0.629	0.567
Guayaquil, Ecuador 0°-08′ S, 7 m	0.0843	0.0946	0.0562	0.0917	0.0822
Lima, Peru 12° S, 30 m	0.0656	0.0496	0.0784	0.0912	0.712
Chacaltaya, Bolivia 17° S, 5220 m	0.00429	0.0156	0.0105	0.0311	0.0159
Antofagasta, Chile 24° S, 519 m	0.0463	0.0735	0.0620	0.0336	0.0532
Santiago, Chile 33° S, 5 m	0.0584	0.0649	0.0543	0.0681	0.0614
Puerto Montt, Chile 41° S, 5 m	0.0380	0.0448	0.0480	0.0486	0.0450
Punta Arenas, Chile 53° S, 3 m	0.0147	0.0283	0.0395	0.0240	0.0266

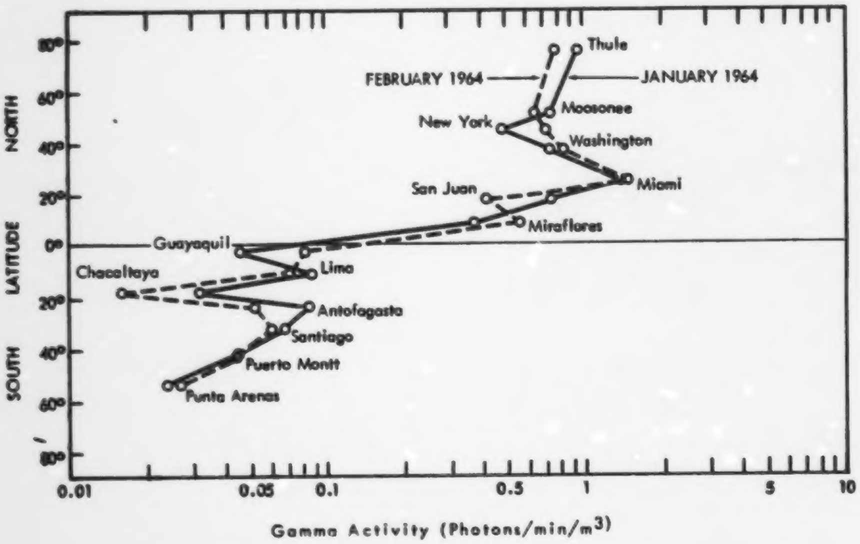

FIGURE 2.—PROFILE OF SURFACE AIR GAMMA ACTIVITY, JANUARY AND FEBRUARY 1964

15

Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, March 1964

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. Composites of the samples are preserved with formaldehyde and are sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL) for analysis. Gamma analyses for iodine-131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after collection; publication in *RHD* follows 3 to 4 months after sample collection.

Sampling and Compositing Procedures

The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Analytical Errors

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectroscopy.[1] After gamma scanning, samples from two consecutive weeks are composited and analyzed radiochemically for strontium–89 and strontium–90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation is dependent upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for low background beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing results of a large number of analyses. The ± 2 standard deviations (2σ) about the measured concentration correspond to a 95 percent certainty that the true concentration is within this range. The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error [a] (pc/liter)	Estimated concentration (pc/liter)	Error [a] (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10%
Barium-140	0 to 100	±10	100 or greater	±10%
Cesium-137	0 to 100	±10	100 or greater	±10%
Strontium-89	0 to 50	±5	50 or greater	±10%
Strontium-90	0 to 20	±2	20 or greater	±10%

[a] Two standard deviations (2σ).

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium–40 concentrations[2] determined from the gamma spectrum.

Data Presentation

Table 2 presents summaries of the analyses for March 1964 (March 1–28, 1964). Although not shown in table 2, the iodine–131 and barium–140 monthly average concentrations in milk were less than 10 pc/liter. When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half the minimum detectable value is used as the best approximation in calculating the monthly average. Beginning with October 1963 data, however, zero is used as the best approximation to a nondetectable concentration of iodine–131 or barium–140. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium–90 and cesium–137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modifications to the isograms are made according to available information on milksheds.

In order to develop the distribution of the network's stations versus radionuclide concentrations in milk, table 3 has been prepared using monthly averages shown in table 2.

Continuing the practice followed in previous issues of *RHD*, the average monthly strontium–90 concentrations in pasteurized milk from 16 selected cities in the sampling program are presented in figure 3. Each graph shows the strontium–90 concentrations in milk from one city in each of the four U. S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a year. The last column in table 2 shows the most recent issue in which a graph of the strontium–90 concentration was given for each station.

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

[2] The conversion factor is 1.18×10^{-3} g K/pc K^{40}.

TABLE 2.—STABLE ELEMENT AND RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, MARCH 1964 [a]

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (g/liter)		Potassium (g/liter)		Strontium-89		Strontium-90		Cesium-137		Last Sr^{90} graph in *RHD* (1964)
		First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	
Ala:	Montgomery	1.19	1.12	1.5	1.5	<5	<5	24	25	100	95	June
Alaska:	Palmer	1.16	1.16	1.5	1.5	10	5	23	18	160	140	July
Ariz:	Phoenix	1.18	1.18	1.5	1.5	<5	<5	4	4	25	30	May
Ark:	Little Rock	1.18	1.14	1.5	1.5	<5	5	43	50	165	175	July
Calif:	Sacramento	1.25	1.26	1.6	1.5	<5	<5	11	12	65	70	April
	San Francisco	1.23	1.26	1.5	1.4	<5	<5	13	14	75	70	June
Canal Zone:	Cristobal	1.15	1.11	1.6	1.6	<5	<5	6	6	50	50	July
Colo:	Denver	1.23	1.22	1.6	1.5	<5	5	19	19	90	100	April
Conn:	Hartford	1.15	1.14	1.6	1.6	<5	<5	23	24	185	190	April
Del:	Wilmington	1.21	1.23	1.6	1.6	<5	<5	21	22	150	160	May
D. C:	Washington	1.17	1.13	1.6	1.6	<5	<5	18	18	105	110	June
Fla:	Tampa	1.21	1.14	1.5	1.5	<5	<5	15	14	200	225	May
Ga:	Atlanta	1.21	1.16	1.6	1.5	<5	<5	35	36	160	180	June
Hawaii:	Honolulu	1.18	1.15	1.6	1.6	<5	<5	11	11	80	85	July
Idaho:	Idaho Falls	1.19	1.22	1.6	1.5	5	<5	27	10	220	215	May
Ill:	Chicago	1.18	1.18	1.6	1.6	<5	<5	21	20	145	150	June
Ind:	Indianapolis	1.22	1.22	1.6	1.6	<5	<5	22	20	120	130	April
Iowa:	Des Moines	1.22	1.24	1.5	1.4	<5	5	27	26	110	110	May
Kans:	Wichita	1.21	1.20	1.5	1.4	10	10	23	24	80	85	July
Ky:	Louisville	1.18	1.14	1.6	1.5	<5	<5	32	34	125	130	May
La:	New Orleans	1.22	1.17	1.5	1.5	<5	<5	54	64	165	190	July
Maine:	Portland	1.20	1.22	1.6	1.6	<5	<5	31	30	220	215	May
Md:	Baltimore	1.17	1.12	1.5	1.5	<5	<5	20	22	115	125	May
Mass:	Boston	1.20	1.21	1.6	1.6	<5	<5	32	28	265	270	June
Mich:	Detroit	1.19	1.20	1.6	1.6	<5	<5	19	18	135	135	April
	Grand Rapids	1.21	1.22	1.5	1.6	<5	<5	22	19	145	150	May
Minn:	Minneapolis	1.18	1.22	1.6	1.5	10	20	35	30	190	195	June
Miss:	Jackson	1.26	1.26	1.5	1.5	5	<5	41	48	125	135	April
Mo:	Kansas City	1.22	1.28	1.5	1.4	5	5	28	27	100	100	April
	St. Louis	1.20	1.19	1.5	1.5	5	<5	23	24	100	105	July
Mont:	Helena	1.22	1.24	1.5	1.5	10	10	31	31	235	235	July
Nebr:	Omaha	1.21	1.26	1.5	1.4	5	<5	25	26	105	110	May
Nev:	Las Vegas	1.24	1.21	1.6	1.5	<5	<5	15	13	95	100	June
N. H:	Manchester	1.22	1.25	1.7	1.6	<5	<5	32	28	260	255	May
N. J:	Trenton	1.19	1.20	1.6	1.6	5	<5	18	18	140	150	April
N. Mex:	Albuquerque	1.19	1.22	1.5	1.4	<5	5	12	11	60	60	July
N. Y:	Buffalo	1.16	1.17	1.6	1.6	<5	<5	20	20	170	175	April
	New York	1.16	1.18	1.6	1.7	<5	<5	25	22	190	195	June
	Syracuse	1.18	1.16	1.6	1.6	<5	<5	22	20	170	180	July
N. C:	Charlotte	1.22	1.18	1.5	1.5	<5	<5	31	36	115	120	July
N. Dak:	Minot	1.21	1.24	1.5	1.4	15	30	58	39	160	155	May
Ohio:	Cincinnati	1.21	1.20	1.6	1.6	<5	<5	24	25	125	120	April
	Cleveland	1.21	1.19	1.6	1.6	<5	<5	22	23	135	145	July
Okla:	Oklahoma City	1.18	1.12	1.6	1.5	<5	<5	25	26	90	90	June
Ore:	Portland	1.24	1.28	1.5	1.4	5	<5	27	26	155	150	April
Pa:	Philadelphia	1.21	1.22	1.6	1.5	<5	<5	20	20	145	150	July
	Pittsburgh	1.19	1.19	1.6	1.6	<5	<5	28	28	170	175	July
P. R:	San Juan	1.16	1.12	1.6	1.6	<5	<5	12	13	70	85	July
R. I:	Providence	1.18	1.18	1.6	1.6	<5	<5	25	25	185	185	May
S. C:	Charleston	1.18	1.12	1.5	1.5	<5	<5	34	34	135	140	April
S. Dak:	Rapid City	1.19	1.20	1.5	1.5	10	10	38	30	175	175	June
Tenn:	Chattanooga	1.23	1.20	1.5	1.4	5	<5	38	44	145	155	June
	Memphis	1.21	1.14	1.5	1.6	<5	<5	32	36	90	95	May
Tex:	Austin	1.17	1.12	1.6	1.5	<5	<5	10	11	45	45	June
	Dallas	1.19	1.14	1.6	1.6	<5	<5	22	24	85	85	April
Utah:	Salt Lake City	1.21	1.16	1.5	1.4	5	10	27	26	215	235	July
Vt:	Burlington	1.18	1.18	1.6	1.6	<5	<5	26	23	210	210	April
Va:	Norfolk	1.18	1.14	1.6	1.6	<5	<5	20	22	105	110	April
Wash:	Seattle	1.21	1.23	1.5	1.5	10	10	21	24	120	125	June
	Spokane	1.24	1.26	1.6	1.5	5	5	33	24	145	140	April
W. Va:	Charleston	1.18	1.14	1.5	1.5	<5	<5	26	28	110	110	June
Wis:	Milwaukee	1.22	1.22	1.7	1.8	<5	<5	19	18	160	160	May
Wyo:	Laramie	1.18	1.23	1.5	1.4	10	15	21	19	115	130	May
Network average		1.20	1.19	1.6	1.5	<5	<5	24.8	24.3	136	141	Nov. 63

[a] The monthly average iodine-131 and barium-140 concentration at each station was <10 pc/liter.

18

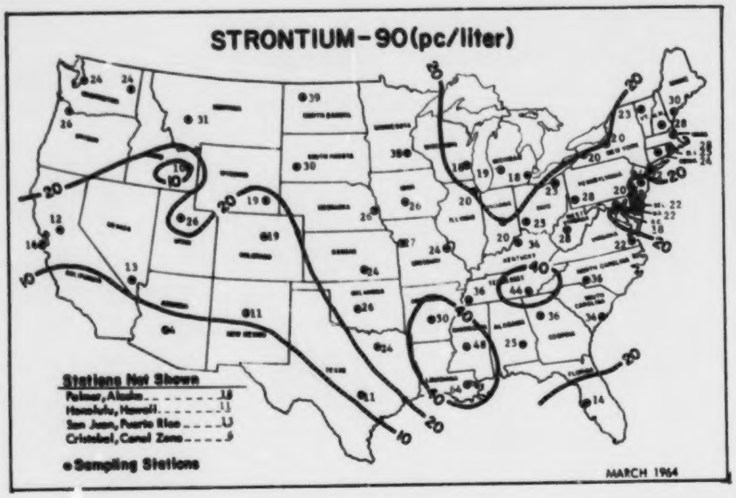
STRONTIUM-90 (pc/liter)
Stations Not Shown
Palmer, Alaska 18
Honolulu, Hawaii 11
San Juan, Puerto Rico 13
Cristobal, Canal Zone 9
● Sampling Stations
MARCH 1964

FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, MARCH 1964

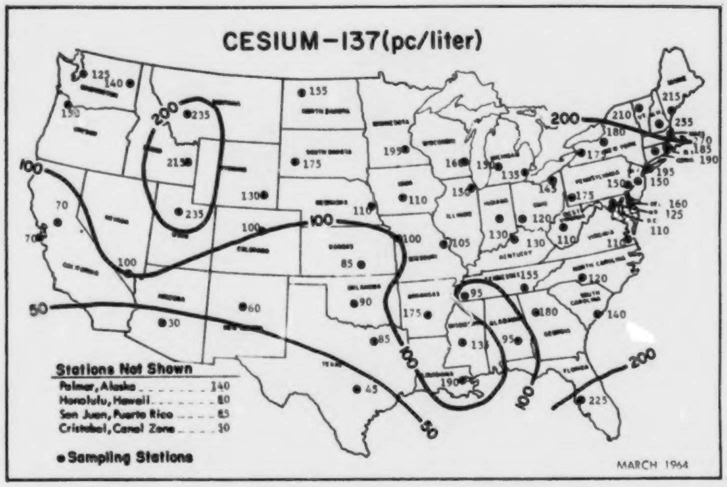
CESIUM-137 (pc/liter)
Stations Not Shown
Palmer, Alaska 140
Honolulu, Hawaii 80
San Juan, Puerto Rico 85
Cristobal, Canal Zone 30
● Sampling Stations
MARCH 1964

FIGURE 2.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK, MARCH 1964

TABLE 3.—DISTRIBUTION OF SAMPLING STATIONS IN VARIOUS RANGES OF RADIONUCLIDE CONCENTRATIONS IN MILK, MARCH 1964

Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations
<5	48	<1-9	2	<10	63	<5-45	2	<10	63
5	7	10-14	9			50-95	11		
10	5	15-19	8			100-145	22		
15	1	20-24	17			150-195	20		
20	1	25-29	13			200-245	6		
25	0	30-34	6			250-295	2		
30	1	35-39	4						
		40-69	4						
Total	63	Total	63	Total	63	Total	63	Total	63

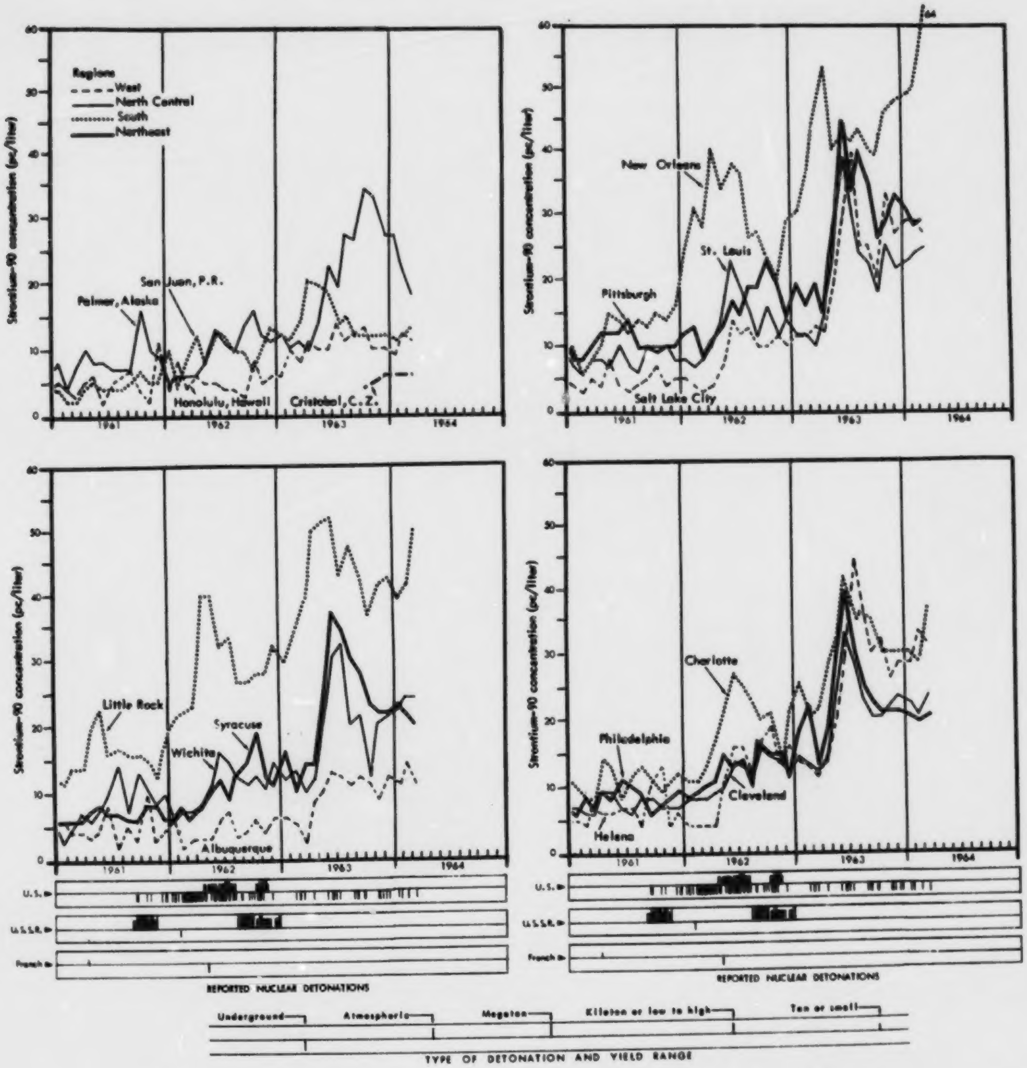

FIGURE 3.—STRONTIUM-90 IN PASTEURIZED MILK, 1961–MARCH 1964

Monthly network maximum, minimum, and average radionuclide levels in milk summarized in table 4 are helpful in showing the variability of results about the average and trends of the U. S. milk data since March 1960. When strontium–89 concentrations have been detectable, the ratio of the network maximum to the network average has ranged from 2.5 to 12.0 but was less than 4.0 a majority of the time. For iodine–131 the ratio of maximum to average concentration has been somewhat higher, ranging from 2.4 to 16.5. The strontium–90 maximum to average ratio has exceeded 3.0 only three times since March 1960. Furthermore, the ratio

20

TABLE 4.—NETWORK MONTHLY MAXIMUM, MINIMUM, AND AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK, MARCH 1960–MARCH 1964

[Concentrations in pc/liter]

Year and month	Number of stations in the network	Strontium-89			Strontium-90			Iodine-131			Cesium-137		
		Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
1960													
Mar	5	10	[a] 0	0	8	3	6	0	0	0	[b] —	[b] —	[b] —
Apr	18	20	0	5	16	2	8	0	0	0	45	<10	20
May	19	5	0	0	15	4	8	0	0	0	50	<10	25
June	33	0	0	0	18	2	9	0	0	0	40	<10	20
July	45	10	0	0	18	2	9	0	0	0	70	<10	15
Aug	57	0	0	0	14	1	7	0	0	0	80	<10	10
Sept	58	0	0	0	16	2	8	0	0	0	85	<10	5
Oct	58	0	0	0	12	2	7	0	0	0	75	<5	5
Nov	58	0	0	0	14	1	7	0	0	0	80	<5	10
Dec	58	0	0	0	14	2	8	0	0	0	50	<5	5
1961													
Jan	58	0	0	0	12	2	7	0	0	0	40	<5	<5
Feb	58	0	0	0	14	1	6	0	0	0	25	<5	5
Mar	58	0	0	0	14	2	7	0	0	0	40	<5	5
Apr	58	0	0	0	20	3	8	0	0	0	90	<5	10
May	58	0	0	0	22	4	9	0	0	0	110	<5	15
June	58	0	0	0	16	2	9	0	0	0	130	<5	25
July	58	0	0	0	17	2	8	0	0	0	70	<5	15
Aug	58	0	0	0	16	2	8	0	0	0	85	<5	10
Sept	[c] 59	30	<5	10	16	3	8	[d] (340)	10	(100)	100	<5	15
Oct	60	170	<5	40	17	3	9	540	20	100	75	<5	15
Nov	60	180	<5	55	33	2	9	210	20	60	90	<5	10
Dec	60	205	<5	35	17	2	9	50	<10	10	40	<5	10
1962													
Jan	61	300	<5	25	24	2	8.5	20	<10	<10	50	<5	9
Feb	61	365	<5	31	31	2	8.7	20	<10	<10	65	<5	9
Mar	61	315	<5	35	28	3	8.6	20	<10	<10	100	<5	16
Apr	61	380	<5	63	40	3	12.0	10	<10	<10	135	<5	25
May	61	220	5	60	40	2	13.9	220	<10	21	155	<5	38
June	61	215	5	71	40	3	17.4	350	<10	30	120	<5	61
July	62	145	10	53	36	2	15.6	580	<10	38	100	20	67
Aug	62	150	5	50	27	2	14.1	330	<10	20	155	15	65
Sept	62	175	<5	44	28	2	14.5	730	<10	62	140	10	54
Oct	62	150	5	56	29	2	16.0	270	<10	61	130	15	58
Nov	62	200	10	57	28	4	14.6	170	10	70	140	15	62
Dec	62	195	15	50	33	4	14.6	330	<10	51	115	20	66
1963													
Jan	62	170	<5	34	30	3	15.4	40	<10	14	110	20	66
Feb	62	270	<5	33	36	3	15.4	30	<10	<10	135	25	72
Mar	62	385	<5	44	44	2	15.8	20	<10	<10	165	20	70
Apr	62	250	<5	59	53	4	19.1	20	<10	<10	185	15	79
May	62	235	20	95	56	6	26.5	<10	<10	<10	210	20	107
June	62	320	10	106	62	5	32.0	10	<10	<10	270	10	149
July	62	195	10	77	67	3	31.4	<10	<10	<10	380	15	163
Aug	62	125	5	47	58	3	28.1	<10	<10	<10	380	25	150
Sept	62	100	<5	31	56	4	25.6	<10	<10	<10	310	30	128
Oct	63	75	<5	18	54	2	23.1	0	0	0	285	30	115
Nov	63	25	<5	9	50	4	24.8	0	0	0	280	30	125
Dec	63	20	<5	5	60	3	24.6	0	0	0	280	25	130
1964													
Jan	63	10	<5	<5	68	4	24.9	0	0	0	265	20	134
Feb	63	10	<5	<5	67	5	25.3	0	0	0	260	20	135
Mar	63	20	<5	<5	64	4	24.3	0	0	0	270	30	141

[a] Zero was used in calculations and indicates no detectable activity.
[b] Dash indicates no analysis performed.
[c] Only 17 stations collected samples during the latter part of September.
[d] Values in parentheses are estimates based upon data from the next month.

has dropped below 1.9 only infrequently. Of the four nuclides for which determinations are being made, the monthly maximum strontium-90 concentrations have generally not varied from the network average by as large a factor as the other nuclides. Before 1962, the ratio of network maximum to average cesium-137 monthly average concentrations ranged from 2.0 to 17.0. In 1962 this ratio ranged to 7.2 and more recently in 1963 and 1964 has not exceeded 2.5. This decrease may be explained by the generally rising levels throughout the network since 1962.

2. Indiana Milk Network, March 1964

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analysis in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (figure 4).

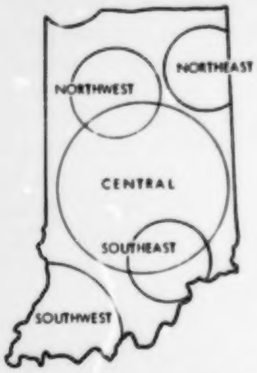

FIGURE 4.—INDIANA MILK SAMPLING LOCATIONS

The milk samples are routinely analyzed for iodine-131, cesium-137, barium-140, strontium-89 and strontium-90. Until August 1963, analyses for the gamma emitters iodine-131, cesium-137 and barium-140 were conducted on a weekly basis, except when iodine-131 exceeded 100 pc/liter, at which times the frequency of sampling was increased. Because of continued low concentrations of the short-lived gamma emitters, the sampling frequency was reduced in August 1963 to once per month for the northeast, southeast and southwest milksheds. Strontium-89 and strontium-90 analyses are performed monthly for each station.

An ion exchange analytical procedure (2) is employed for strontium-89 and strontium-90 analyses. Minimum detectable levels for strontium-89 and strontium-90 are about 5 and 1 pc/liter, respectively. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine-131, cesium-137, and barium-140. The lower limit of detectability for both iodine-131 and barium-140 is 5 pc/liter. Cesium-137 analyses are subject to a 6 percent error at the 100 pc/liter level.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 5. The State average is an arithmetic average of the station values.

TABLE 5.—RADIONUCLIDES IN INDIANA MILK, MARCH 1964 [a]

[Radionuclide concentrations in pc/liter]

Sampling location	Calcium (g/liter)	K^{40}	Sr^{90}	Cs^{137}
Northeast	1.20	1240	19	115
Southeast	1.20	1250	25	105
Central	1.18	1300	21	110
Southwest	1.17	1290	27	110
Northwest	1.18	1270	25	125
Average	1.17	1280	23	115

[a] The monthly average iodine-131, barium-140, and strontium-89 concentration at each station was zero.

3. New York Milk Network, January 1964

Division of Environmental Health Services,
State of New York Department of Health

Milk samples collected routinely from six cities—Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 5)—are analyzed for their radionuclide content by the New York State Deportment of Health. Pasteurized milk samples are collected daily and composited weekly for the determination of strontium-89, strontium-90, iodine-131, cesium-137 and barium-lanthanum-140 at all

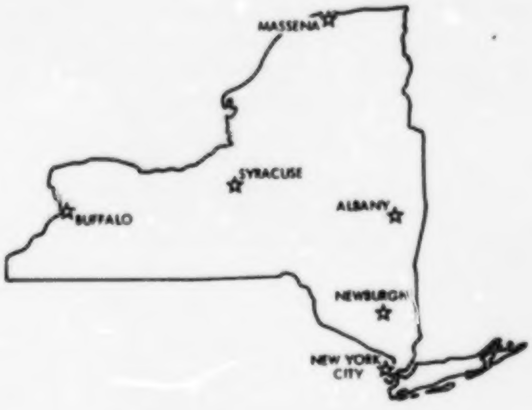

FIGURE 5.—NEW YORK MILK SAMPLING LOCATIONS

22

stations except Massena, where samples are composited bi-weekly, and at New York City where one daily milk sample representing the total milk supply for that day is obtained and analyzed once a week. Samples are obtained from processing plants except at Albany, where the daily sample is obtained from a marketing point. During periods when cows are no longer on stored feed, the sample from Albany is analyzed daily for iodine–131. In the event that any city reports iodine–131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken.

A matrix method (*3*) is used for the analysis of spectral data to determine the concentrations of gamma-emitting nuclides in milk. With this method, the individual nuclide contributions to the gamma spectrum are separated by solution of simultaneous equations describing the spectral interferences.

The analytical procedure for strontium–89 and strontium–90 is based on ion exchange methods. Cations (including radiostrontium) are eluted from the ion exchange resin with sodium chloride solution, strontium isotopes are gathered by means of sodium carbonate, isolated by means of ethylenediaminetetraacetic acid (EDTA), and radiostrontium is counted with a low background beta counter having an 0.8 mg/cm^2 window. The strontium–90 portion is differentially estimated by a second count 40 hours later to determine the rate of ingrowth of its daughter product yttrium–90. The monthly average radionuclide concentrations in milk are shown in table 6.

TABLE 6.—RADIONUCLIDES IN NEW YORK MILK, JANUARY 1964 [a]

[Average concentrations in pc/liter]

Sampling location	Strontium-89	Strontium-90	Cesium-137
Albany	5	20	125
Buffalo	6	13	109
Massena	4	28	204
Newburgh	7	23	131
New York City	6	25	133
Syracuse	6	19	123
Average	6	21	138

[a] The monthly average I^{131} and $Ba-La^{140}$ at each station was <20 pc/liter. $Ba-La^{140}$ refers to the sum of these nuclides in equilibrium.

4. Pennsylvania Milk Network, December 1963—March 1964

Bureau of Environmental Health,
Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from 10 major milk consumption areas throughout Pennsylvania (figure 6). Two samples per week are collected in Philadelphia and Pittsburgh, while weekly composite samples are collected from the other eight stations. At each sampling location subsamples are collected from the major dairies supplying the area and are composited in proportion to the amount of milk processed by each dairy. This composite sample is then sent to the Radiation Laboratory of the Division of Occupational Health in Harrisburg, where the weekly samples are combined for monthly analyses. Iodine–131 analyses were carried out from September 1962 through February 1963, when concentrations fell to non-detectable levels. Since April 1963, samples have been analyzed for strontium–90. The gamma analyses of these samples for potassium–40, iodine–131, cesium–137, and barium–140-lanthanum–140 were begun in March 1964.

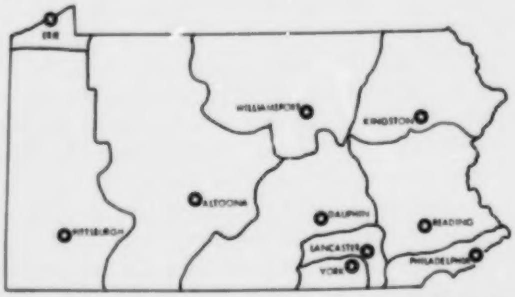

FIGURE 6.—PENNSYLVANIA MILK SAMPLING STATIONS AND MILK CONSUMPTION AREAS

The chemical separation technique for strontium–90 is essentially an ion exchange method described by Porter, *et al.* (*2*). One liter of milk is passed through an ion exchange column; yttrium–90 is eluted from the resin and is counted in an automatic low background proportional counter.

Samples of whole milk amounting to 3.5 liters are analyzed for gamma emitters with a 4-inch sodium iodide crystal, which is contained in a large steel shield. A multichannel analyzer records the spectra, and the radionuclide content is quantitatively determined by the matrix method.

The monthly average strontium-90 levels in pasteurized milk are shown in table 7 and the monthly average results for gamma emitters are shown in table 8.

TABLE 7.—STRONTIUM-90 IN PENNSYLVANIA MILK, DECEMBER 1963–MARCH 1964

[Concentrations in pc/liter]

Sampling location	December	January	February	March
Altoona	14	21	20	23
Dauphin	16	18	15	27
Erie	18	13	21	24
Kingston	16	10	22	28
Lancaster	18	15	18	21
Philadelphia	17	20	16	25
Pittsburgh	17	16	25	20
Reading	16	15	16	19
Williamsport	17	15	16	20
York	18	12	16	19
State average	16.7	15.5	18.5	22.6

TABLE 8.—GAMMA EMITTING RADIONUCLIDES IN PENNSYLVANIA MILK, MARCH 1964 [a]

[Concentrations in pc/liter]

Sampling location	Cesium-137	Potassium-40
Altoona	160	1,334
Dauphin	111	1,445
Erie	133	1,582
Kingston	178	1,773
Lancaster	138	1,463
Philadelphia	124	1,501
Pittsburgh	123	1,633
Reading	121	1,542
Williamsport	137	1,728
York	145	1,624
State average	137	1,563

[a] The monthly average I^{131} and Ba^{140}-La^{140} at each station was <10 pc/liter.

5. Radiostrontium in Milk,[3] October–December 1963

Health and Safety Laboratory,
U. S. Atomic Energy Commission

The Health and Safety Laboratory began monitoring liquid whole milk in New York City in 1954 for strontium-90 in order to estimate the dietary contribution from the ingestion of radiostrontium in milk. Subsequently, powdered milk monitoring was initiated at Perry, New York, in 1954 and at Mandan, North Dakota in 1955. Liquid whole milk monitoring was started in Honolulu, Hawaii, in August 1959.

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Honolulu samples are monthly composites of quart samples of pasteurized milk collected weekly. Samples from two dairies are analyzed and the results are averaged. The Mandan and Perry samples are monthly composites of powdered milk collected in 5-pound lots from plants in each city. The Mandan sample is powdered buttermilk used in cattle feeds. Because of its protein and fat content, this buttermilk powder is used primarily as a milk replacer or feed supplement for calves. The Perry sample is powdered whole milk used for human consumption. The source of the Honolulu milk is from the island of Oahu where the cows are on pasture throughout the year, and it is of interest to know how closely the strontium levels in milk in this area reflect changes in deposition rates.

The calcium and strontium-90 data are presented in table 9. The fluctuations of strontium-90 with time are shown in figures 7 and 8.

TABLE 9.—STRONTIUM-90 AND CALCIUM IN MILK, OCTOBER-DECEMBER 1963

Sampling station and 1963 period	Calcium concentration	Strontium-90 concentration	Strontium/Calcium ratio
Liquid Milk	(g/liter)	(pc/liter)	(pc/g Ca)
New York City			
Third Quarter			34.5
October	1.07	31.6	29.6
November	1.09	28.2	25.9
December	0.80	16.5	20.7
Honolulu, Hawaii			
Third Quarter			8.0
October	1.06	13.1	12.5
November	1.13	8.3	7.4
December	1.10	8.2	7.4
Powdered Milk	(g/kg)	(pc/kg)	(pc/g Ca)
Perry, New York			
Third Quarter			29.3
October	8.8	264	30.1
November	9.0	199	22.2
December	9.6	212	22.1
Powdered Buttermilk			
Mandan, North Dakota			
Third Quarter			57.8
October	11.2	937	83.7
November	11.2	842	75.6
December	12.2	836	68.6

Comment

A marked increase in the strontium-90 content of milk from the continental U. S. stations was observed beginning in May 1963, due to the heavy spring fallout deposition. It is apparent from figures 7 and 8 that the peak strontium-90 concentrations were reached in the summer.

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[3] Data summarized from *Health and Safety Laboratory, AEC, Fallout Program Quarterly Summary Report, HASL-144*: 175-83, Office of Technical Services, Department of Commerce, Washington, D. C. 20230 (April 1, 1964), price $4.00.

The Honolulu milk samples still contain less strontium-90 per liter than those of other sampling stations, although there was also a slight increase in strontium-90 concentrations in the Honolulu samples in May.

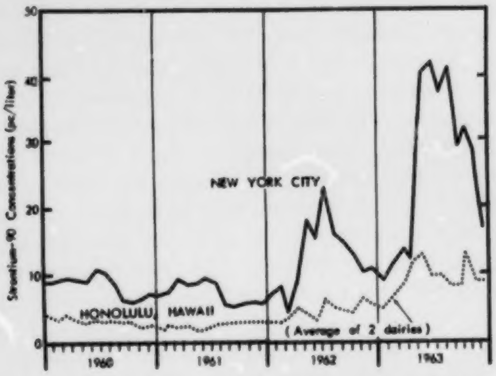

Figure 7.—STRONTIUM-90 IN LIQUID MILK

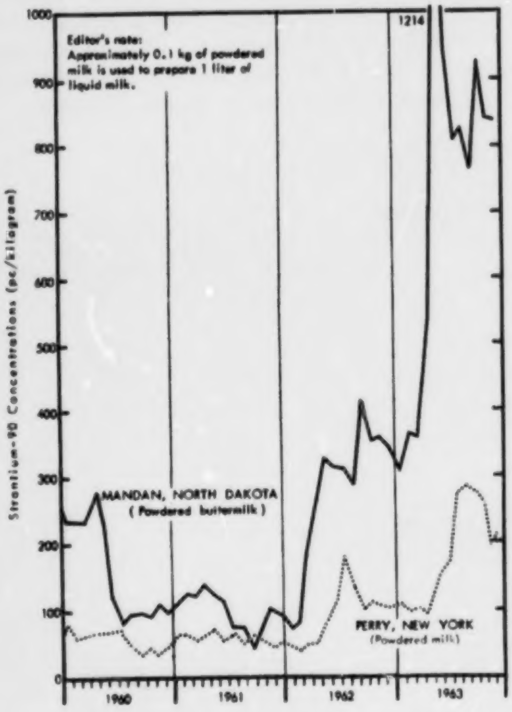

Figure 8.—STRONTIUM-90 IN POWDERED MILK

Recent coverage in *Radiological Health Data:*

Period	Issue
March–June 1962	*January 1963*
July–September 1962	*April 1963*
October 1962–March 1963	*October 1963*
April–June 1963	*January 1964*
July–September 1963	*April 1964*

6. Canadian Milk Network,[4] March 1964

Radiation Protection Division
Department of National Health and Welfare,
Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium-90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963, liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and in addition it is possible to choose milk sampling locations (see figure 9) in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine-131, strontium-89, cesium-137 and strontium-90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine-131. The results of the spot checks for iodine-131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium-90, strontium-89, cesium-137, and stable potassium and calcium.

Analytical Methods

Radiochemical methods are used for the analysis of iodine-131 (*4*). Carrier iodine is added and the milk is then evaporated in the presence of sodium hydroxide and ashed. The iodide ion is oxidized to free iodine and extracted with carbon tetrachloride, back-extracted in sulfite solution, and precipitated as silver iodide. The precipitate is counted in a low background beta counter and the iodine–131 determined by comparison with standard preparations.

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[4] Data from *Radiation Protection Programs, Vol. 2, No. 4*:25–30, Radiation Protection Division, Canadian Department of National Health and Welfare (April 1964).

25

For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk; the milk is then placed in a tray lined with a polyethylene sheet, and evaporated under infra-red lamps. The residue is ashed in a muffle furnace at 450°C, dissolved in dilute nitric acid, and strontium separated by fuming nitric acid precipitation. The combined strontium–89 and strontium–90 are determined by counting in a low background beta counter. Strontium–90 is determined separately by extracting and counting the yttrium–90 daughter nuclide while strontium–89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium–137 is determined by gamma spectroscopy using a scintillation crystal and a multi-channel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium–40 and cesium–137 content of the milk by comparison of the spectrum with standard preparations. The stable potassium content is estimated from the potassium–40 concentration.

Sources of Error

In the iodide and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the determination of cesium–137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 10.

TABLE 10.—TOTAL ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS IN MILK [a]

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Strontium-89	±25%	±20%	±15%
Strontium-90	±15%	±10%	±10%
Iodine-131	±50%	±20%	±10%
Cesium-137	±60%	±25%	±10%

[a] All errors are 2σ values, representing 95 percent confidence.

Results

Table 11 presents monthly averages of strontium–90, cesium–137, stable calcium, and potas-

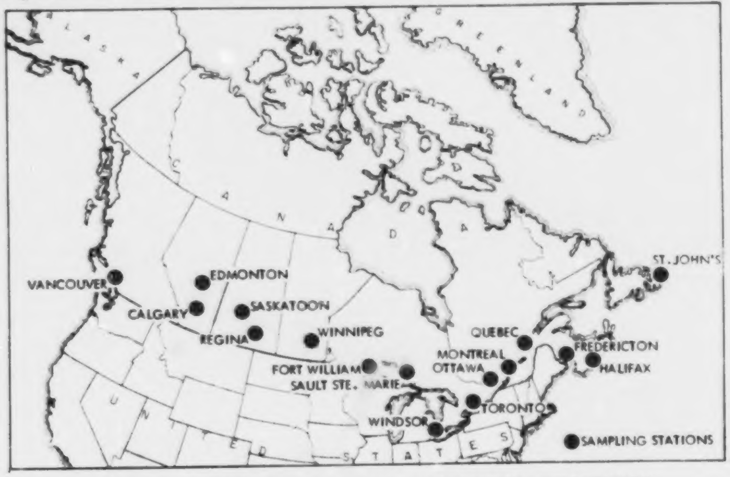

FIGURE 9.—CANADIAN MILK SAMPLING STATIONS

sium in Canadian whole milk. Spot checks for strontium-89 and iodine-131 indicate that all samples had <5 pc/liter. Figure 10 shows the variation of the network average of the radionuclide concentration in Canadian whole milk.

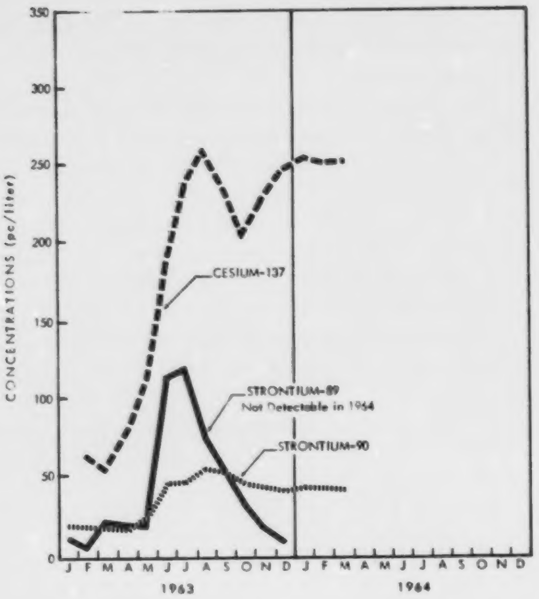

FIGURE 10.—NETWORK AVERAGE STRONTIUM-89, STRONTIUM-90, AND CESIUM-137 CONCENTRATIONS IN CANADIAN WHOLE MILK

TABLE 11.—RADIONUCLIDES IN CANADIAN WHOLE MILK, MARCH 1964

[Radionuclide concentrations in pc/liter]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90	Cesium-137
Calgary	1.38	1.6	52.4	229
Edmonton	1.30	1.5	36.1	296
Ft. William	1.34	1.6	57.2	293
Fredericton	1.41	1.6	49.9	378
Halifax	1.40	1.6	39.7	291
Montreal	1.32	1.6	40.2	280
Ottawa	1.36	1.7	32.0	226
Quebec	1.30	1.6	47.6	341
Regina	1.29	1.6	46.0	211
St. John's, Nfld	1.32	1.6	41.4	259
Saskatoon	1.35	1.7	50.5	224
Sault Ste. Marie	1.38	1.6	35.9	212
Toronto	1.43	1.5	17.6	149
Vancouver	1.41	1.6	37.5	272
Windsor	1.41	1.6	17.8	110
Winnipeg	1.30	1.6	47.7	249
Average	1.36	1.6	40.6	251

REFERENCES

(*1*) Public Health Service: Summary of Results from the Raw Milk Sampling Program, June 1957–April 1963, *Radiological Health Data, 4:* 511–23 (October 1963).

(*2*) Porter, C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determination of Strontium-90 in Milk by an Ion Exchange Method, *Analytical Chemistry, 33:* 1306–8 (September 1961).

(*3*) Kahn, B., *et al.*: *Rapid Methods for Estimating Fission Product Concentrations in Milk, Public Health Service Publication No. 999–R–2,* (March 1963). Single copies available on request from Public Inquiries Branch, PHS, U.S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

(*4*) DasGupta, A. K., and H. G. Green: *A Method for the Radiochemical Determination of Iodine–131 in Milk, RPD–23,* Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada (October 1963).

MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, APRIL 1963—MARCH 1964

Division of Radiological Health, Public Health Service

Radionuclide concentration values reported by the Pasteurized Milk Network (*1*) can be used to estimate the contribution of milk to a population's radiation exposure. This is done by determining both the annual average concentrations of specific radionuclides in milk and the average daily milk consumption of a representative individual in a suitable sample of the population.

The data listed in table 1 are concerned with the first of these requirements, *i.e.*, annual average concentrations of strontium–89, strontium–90, iodine–131 and cesium–137 in one liter of pasteurized milk. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U.S. population (*2, 3*).

To arrive at a basis of comparison between the daily rates of intake of the radionuclides from the milk component of the diet and the Federal Radiation Council's ranges of transient daily rates of intake (*4*), it is assumed that the average daily milk consumption of an individual in a population group is one liter. The Guides, however, apply to total intake from all sources. The upper limits of Range II correspond to the Radiation Protection Guide (RPG) for iodine–131 and one third of the Radiation Protection Guide for radioactive strontium. The Guides are, for administrative reasons, expressed as a yearly radiation dose, but are based on lifetime exposure (*5*). The FRC emphasizes that the annual acceptable risk or exposure dose is not a dividing line between safety and danger in actual radiation situations (*6*).

Annual averages of radionuclide concentrations in milk sampled by the PHS Pasteurized Milk Network are presented in table 1. The data in table 1 are calculated as follows: Results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of twelve consecutive months are averaged to obtain the annual average.[a] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk (*3, 4*).

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as weather conditions and dairying practices. The moving yearly average (table 1), obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

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(*1*) Public Health Service: Milk Surveillance—Pasteurized Milk Network, *Radiological Health Data*, *5*:57–61 (February 1964).

(*2*) Bureau of the Census, and Public Health Service: National Food Consumption Survey, Fresh Whole Milk Consumption in the United States, July 1962, *Radiological Health Data 4*:15–17 (January 1963).

(*3*) Bureau of the Census and Public Health Service: Consumption of Selected Food Items in U. S. Households, July 1962, *Radiological Health Data*, *4*:124–7 (March 1963).

(*4*) Federal Radiation Council: Radiation Protection Guidance for Federal Agencies, *Federal Register*: 9057–8, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (September 26, 1961).

(*5*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (September 1961). Price 20 cents.

(*6*) Public Health Service: Special Report, *Radiological Health Data*, *3*:ii–iii, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (September 1962).

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[a] Beginning with the October 1963 data, iodine–131 values of <10 pc/liter are considered to be zero for averaging purposes; previously 5 pc/liter was used in calculating the average.

TABLE 1.—MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK

[Concentrations in pc/liter]

Sampling locations		Strontium-89		Strontium-90		Cesium-137	
		March 1963—February 1964 [a]	April 1963—March 1964 [b]	March 1963—February 1964 [a]	April 1963—March 1964 [b]	March 1963—February 1964 [a]	April 1963—March 1964 [b]
Ala:	Montgomery	46	38	22	22	85	89
Alaska:	Palmer	29	28	23	24	132	140
Ariz:	Phoenix	9	8	4	4	22	22
Ark:	Little Rock	91	80	43	44	160	166
Calif:	Sacramento	36	32	11	11	63	66
	San Francisco	62	50	14	14	77	79
Colo:	Denver	24	23	17	18	86	90
Conn:	Hartford	21	21	24	26	161	173
Del:	Wilmington	27	27	25	26	133	141
D. C:	Washington	37	37	20	20	100	105
Fla:	Tampa	24	18	15	15	225	231
Ga:	Atlanta	67	58	31	32	148	156
Hawaii:	Honolulu	28	20	11	11	76	79
Idaho:	Idaho Falls	47	48	27	27	154	167
Ill:	Chicago	18	18	21	21	113	120
Ind:	Indianapolis	27	26	24	24	102	108
Iowa:	Des Moines	54	54	26	28	93	98
Kans:	Wichita	37	37	20	22	74	78
Ky:	Louisville	79	76	33	35	113	121
La:	New Orleans	101	68	44	46	156	158
Maine:	Portland	25	26	32	33	209	220
Md:	Baltimore	45	45	21	22	123	129
Mass:	Boston	30	31	36	36	232	248
Mich:	Detroit	16	16	20	20	114	119
	Grand Rapids	17	17	21	21	120	127
Minn:	Minneapolis	46	47	32	33	153	161
Miss:	Jackson	98	69	37	37	116	119
Mo:	Kansas City	61	60	28	30	86	91
	St. Louis	45	43	23	24	88	93
Mont:	Helena	43	43	28	30	182	195
Nebr:	Omaha	46	45	26	27	97	103
Nev:	Las Vegas	15	15	10	11	72	77
N. H:	Manchester	28	29	34	35	254	268
N. J:	Trenton	21	21	22	22	124	132
N. Mex:	Albuquerque	18	17	10	11	46	49
N. Y:	Buffalo	21	21	23	23	141	149
	New York	29	29	30	31	165	178
	Syracuse	23	24	24	25	138	148
N. C:	Charlotte	61	58	32	33	123	128
N. Dak:	Minot	80	81	53	55	143	150
Ohio:	Cincinnati	33	32	26	27	95	101
	Cleveland	22	23	22	23	110	117
Okla:	Oklahoma City	53	48	24	24	90	93
Ore:	Portland	63	60	31	32	162	171
Pa:	Philadelphia	25	25	23	24	126	134
	Pittsburgh	32	32	29	30	151	160
P. R:	San Juan	45	36	14	14	87	89
R. I:	Providence	25	25	28	29	169	178
S. C:	Charleston	47	38	28	29	128	133
S. Dak:	Rapid City	62	61	40	42	154	164
Tenn:	Chattanooga	94	82	39	40	146	154
	Memphis	73	62	32	33	90	93
Tex:	Austin	22	19	9	10	47	49
	Dallas	51	42	21	21	82	84
Utah:	Salt Lake City	31	31	24	26	162	174
Vt:	Burlington	25	25	29	29	181	193
Va:	Norfolk	40	37	22	22	103	108
Wash:	Seattle	51	50	25	27	150	157
	Spokane	47	47	29	30	141	147
W. Va:	Charleston	62	61	30	31	103	108
Wis:	Milwaukee	17	17	19	20	121	129
Wyo:	Laramie	35	35	22	23	115	119
Network average		42	39	25.2	26.0	124	131

[a] Annual averages were computed on basis of 52 weekly averages.
[b] Annual averages were computed on basis of 53 weekly averages.

29

RADIONUCLIDES IN INSTITUTIONAL DIET SAMPLES, OCTOBER—DECEMBER 1963

Division of Radiological Health, Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program is designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program consisted of sampling diets in eight institutions, but it has since been expanded to 21 boarding schools or institutions, geographically distributed as shown in figure 1. Institutions selected range from financially well-to-do boarding schools to orphanages with severe economic limitations. Each institution (sampling point) except the one at Los Angeles is located in a community from which the PHS Pasteurized Milk Network collects samples. The analytical data from this program supplement the findings for the Institutional Diet Sampling Program.

Sampling Procedure

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Each institution supplies one complete 7-day, 21-meal diet sample each month. Each day's sample is kept frozen during the collection period. After collection, the total sample is packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nevada, the Southeastern Radiological Health Laboratory, Montgomery, Alabama, or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

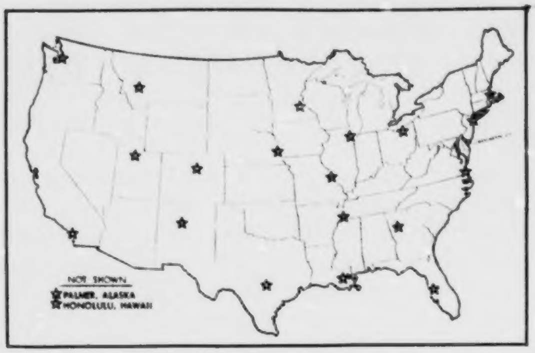


FIGURE 1.—INSTITUTIONAL DIET SAMPLING LOCATIONS

Each sample is packaged in three parts: (1) solid food and semisolid foods minus those portions that would not ordinarily be eaten; (2) liquid milk; (3) other beverages such as soft drinks, coffee and tea. A record of the contents of each meal and the approximate amount of each item is made at the institutions and sent with the sample.

Analytical Procedures

Because calcium and phosphorus compounds may have an effect on the uptake of important bone-seeking radionuclides such as strontium–89 and strontium–90 (*2*), they are included in the analytical program. Total weight, stable calcium, and stable potassium determinations are obtained by conventional gravimetric or spectrophotometric methods. Samples usually range from 6 to 16 liters in volume and weigh from 8 to 20 kilograms. Phosphate determinations are made by a colorimetric technique.

The radioanalysis program is designed around three basic procedures: (1) gamma spectroscopy, (2) chemical separation of strontium–89 and strontium–90 with subsequent counting, and (3) radium–226 analysis. In the absence of interferences other than that from naturally-occurring radioactive potassium (K^{40}), minimum detectable concentrations for the gamma scan expressed as pc/kg are: iodine–131, 10 pc/kg; cesium–137, 5 pc/kg; and barium–140, 10 pc/kg. Approximate minimum detectable concentrations for strontium–89, strontium–90, and radium–226 are: 5, 1 and 1 pc/kg, respectively. Since a constant weight of food is analyzed, the minimum detectable level on a per day basis (pc/day) will be dependent on the food intake.

Data

Table 1 presents the dietary intake data expressed on a per-day basis from October 1963 through December 1963 for the 21 institutions from which samples were received. Also contained in the table is the range of ages of the children from which samples are being obtained. The reported radionuclide concentrations of these samples are extrapolated to the midpoint of the sample collection period.

Certain of the radioanalyses are reported by the laboratories as being "less-than" (<) a specified value. For data averaging, the method employed for presentation in table 1 is that all "less-than" data are assumed to be equal to the full "less-than" values as they appear in the column entitled "monthly maximum averages." The column entitled "monthly minimum averages" reflects the averages in which all "less-than" values are considered to be zero.

The data are presented graphically in figure 2 as a distribution of all sample values observed during the three months versus daily intake. The number of values reported during this quarter in each range is plotted as a frequency-distribution step chart. The number of stations used in constructing these graphs was 21, 21, and 20 for the months of October, November, and December 1963, respectively. Therefore, the total number of samples represented in each chart is 62. Figure 3 shows the overall average daily intake of radionuclides at all institutions since January 1961.

TABLE 1.—INSTITUTIONAL DAILY DIETARY INTAKE

	Month (1963)	Alaska Palmer	California Los Angeles	Colorado Denver	Florida Tampa	Georgia Atlanta	Hawaii Honolulu	Illinois Chicago	Louisiana New Orleans	Massachusetts Boston	Minnesota Minneapolis
Age (years)		6–18	11–18	4–17	6–18	6–18	5–16	6–15	7–18	6–14	[a] <1–16
Total weight (kg/day)	Oct.	1.51	2.58	2.76	2.12	1.60	1.47	[b] 1.21	2.35	1.78	1.52
	Nov.	1.54	1.66	2.12	2.50	1.81	1.81	1.48	2.24	2.07	1.62
	Dec.	1.18	2.02	2.68	2.55	1.70	[c]—	1.94	2.37	1.63	2.68
Calcium (g/day)	Oct.	0.8	1.3	1.6	1.4	0.6	0.6	[b] 0.6	1.9	0.9	0.6
	Nov.	0.8	0.9	1.1	1.6	1.0	1.0	1.1	1.5	1.7	0.9
	Dec.	0.7	1.0	1.0	1.6	1.0	[c]—	1.5	1.5	1.2	1.0
Phosphorus as phosphate (g/day)	Oct.	2.9	5.7	5.4	4.4	3.2	2.5	3.0	6.1	1.9	2.9
	Nov.	3.2	3.8	4.7	5.4	3.6	4.4	2.1	5.6	1.9	2.8
	Dec.	2.5	4.4	5.0	6.2	3.0	[c]—	2.9	4.8	1.4	5.1
Potassium (g/day)	Oct.	3.1	4.8	4.5	2.7	1.8	2.5	[b] 2.2	3.4	2.5	2.6
	Nov.	2.5	2.9	3.1	3.6	2.1	3.2	2.6	3.9	3.2	2.4
	Dec.	2.1	1.7	4.4	3.9	2.1	[c]—	3.4	3.4	2.8	4.2
Radium-226 or total radium [d] (pc/day)	Oct.	4.0	<1.0	<1.0	7.5	3.2	<1.0	1.0	7.7	<1.0	<1.0
	Nov.	<1.0	<1.0	<1.0	<6.1	<3.4	2.0	<1.0	<4.4	<1.0	<1.0
	Dec.	<1.0	<1.0	2.0	5.3	<5.1	[c]—	<1.0	<6.5	<1.0	<1.0
Strontium-89 (pc/day)	Oct.	10	5	15	30	20	5	[b] <5	145	25	20
	Nov.	15	10	10	65	95	10	<10	120	<25	15
	Dec.	5	10	<5	25	15	[c]—	<10	15	<15	<5
Strontium-90 (pc/day)	Oct.	20	11	28	31	25	8	[b] 17	48	28	18
	Nov.	23	11	19	25	30	25	26	52	59	16
	Dec.	12	12	2	46	32	[c]—	41	49	37	3
Cesium-137 (pc/day)	Oct.	160	130	205	370	105	140	[b] 80	220	230	120
	Nov.	140	100	115	420	140	155	155	260	390	140
	Dec.	135	100	120	565	130	[c]—	235	285	280	215
Barium-140 (pc/day)	Oct.	<10	<10	<10	<30	<30	<10	[b] <10	<30	<20	<10
	Nov.	<10	<10	<10	<30	<30	<10	<20	<30	<20	<10
	Dec.	<10	<10	<10	<40	<30	[c]—	<20	<30	<20	<10
Iodine-131 (pc/day)	Oct.	<10	<10	<10	<30	<30	<10	[b] <10	<30	<20	<10
	Nov.	<10	<10	<10	<30	<30	<10	<20	<30	<20	<10
	Dec.	<10	<10	<10	<40	<30	[c]—	<20	<30	<20	<10

[a] Food samples not collected for children too young for solid diet.
[b] Data represent amount in solid food portion of diet only.
[c] A sample was collected but no analysis was performed.
[d] The values for Tampa, Atlanta, New Orleans, Memphis, Austin, and Norfolk are total radium values, not Radium-226.

Discussion of Data

From table 1 it is apparent that the total intake ranged between 1.18 and 2.76 kg/day with an average of about 1.9 kg/day during this quarter. The calcium intake ranged between 0.6 and 2.8 g/day, with twenty-nine percent of the values being less than one g/day. Phosphate intake ranged from 1.4 to 7.1 g/day, with 55 percent of the values ranging from one to 4 g/day. Eighty-nine percent of the samples analyzed for potassium showed that the intake was between 1 and 4 g/day.

All of the 44 samples analyzed for radium-226 ranged between <1 and 5 pc/day with 36 samples having less than 2 pc/day. Eighteen samples were analyzed for total radium (all radium isotopes) and a maximum value of 8.1 pc/day was observed.

Strontium-89 intake ranged between <5 and 145 pc/day. Eighty-two percent of the samples gave values between <5 and 30 pc/day. For purposes of comparison the Federal Radiation Council (FRC) range II for strontium-89 is 200 to 2000 pc/day.

The maximum strontium-90 intake during this quarter was 63 pc/day. Again for comparison, 29 percent of the values were below 20 pc/day. This is similar to last quarter's results. The FRC range II for strontium-90 is 20 to 200 pc/day (*3*).

Although the intake of cesium-137 ranged from 60 to 565 pc/day, the distribution shows a pronounced peak between 120 and 160 pc/day formed by 32 percent of the results. It appears that with respect to cesium-137 intake the situation has been static during the last half of 1963.

Both barium-140 and iodine-131 were below the limits of detectability during this quarter.

(BASED ON A 7-DAY COMPOSITE SAMPLE)

Missouri, St. Louis	Montana Helena	Nebraska Omaha	New Mexico Albuquerque	New York New York	Ohio Cleveland	Tennessee Memphis	Texas Austin	Utah Salt Lake City	Virginia Norfolk	Washington Seattle	Monthly minimum average	Monthly maximum average
7-16	6-17	6-18	5-15	8-15	6-15	8-18	6-18	12-18	10-18	6-16		
2.28 2.47 2.52	1.44 1.75 1.41	1.55 1.50 1.47	1.80 1.88 1.94	2.11 1.80 1.97	1.97 2.07 1.91	1.99 2.17 2.01	2.27 2.30 1.94	1.62 1.26 1.34	2.18 1.99 2.12	1.77 1.82 1.91	1.90 1.90 1.96	1.90 1.90 1.96
1.6 1.5 1.7	0.9 1.2 0.6	0.8 0.9 0.9	1.1 1.7 1.5	[b] 1.6 2.8 1.7	1.8 1.3 1.2	1.3 1.6 1.4	1.5 1.4 1.2	1.1 0.9 0.9	1.2 1.2 1.3	1.1 0.9 1.2	1.2 1.3 1.2	1.2 1.3 1.2
5.5 5.6 7.1	3.0 4.2 2.2	3.1 3.0 3.7	3.6 5.9 4.9	3.2 3.5 3.2	2.2 2.8 2.8	3.9 4.7 4.7	6.8 5.6 3.8	3.2 2.8 3.0	4.0 4.3 5.3	3.5 4.0 4.8	3.8 4.0 4.0	3.8 4.0 4.0
4.3 4.2 4.3	2.3 2.5 1.6	2.8 2.3 2.1	3.1 3.2 3.3	[b] 3.2 2.6 3.6	3.1 3.3 3.6	2.5 3.5 2.7	3.2 3.1 2.2	2.9 2.2 3.0	2.9 2.6 2.6	3.1 2.9 3.0	3.0 2.9 3.0	3.0 2.9 3.0
1.0 1.0 <1.0	1.0 <1.0 <1.0	<1.0 2.0 <1.0	<1.0 2.0 1.0	2.0 2.0 1.0	<1.0 1.0 1.0	4.6 <4.0 2.7	8.1 <3.5 <2.7	<1.0 <1.0 <1.0	4.4 <3.8 4.5	<1.0 <1.0 5.0	2.1 <1.0 1.1	2.6 2.1 2.5
25 10 <5	15 25 10	15 10 5	<5 <5 10	<10 <10 <10	<15 10 <10	30 75 <10	85 85 <10	20 10 15	25 85 10	10 20 20	24 32 7	25 34 11
25 37 5	22 28 17	20 18 25	15 17 17	30 46 40	63 29 30	36 34 38	22 33 24	22 5 21	36 31 32	37 25 27	27 28 26	27 28 26
160 170 200	160 250 150	125 105 105	70 75 60	160 180 255	125 155 195	95 165 120	115 155 115	200 150 235	110 125 140	175 220 160	155 179 190	155 179 190
<10 <10 <10	<10 <10 <10	<10 <10 <10	<10 <10 <10	<20 <20 <20	<20 <20 <20	<30 <30 <30	<30 <30 <30	<10 <10 <10	<30 <30 <30	<10 <10 <10	0 0 0	17 18 18
<10 <10 <10	<10 <10 <10	<10 <10 <10	<10 <10 <10	<20 <20 <20	<20 <20 <20	<30 <30 <30	<30 <30 <30	<10 <10 <10	<30 <30 <30	<10 <10 <10	0 0 0	17 18 18

32

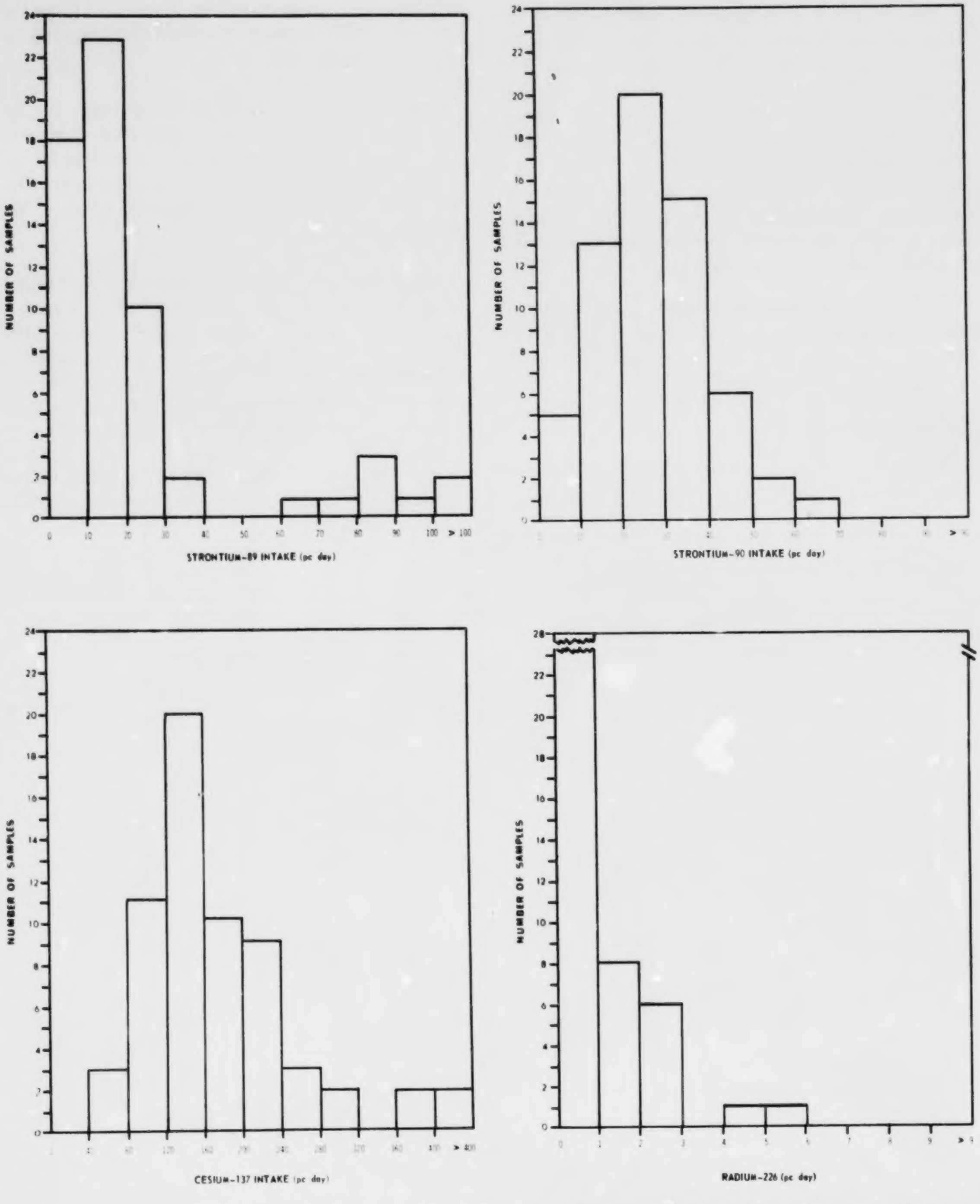
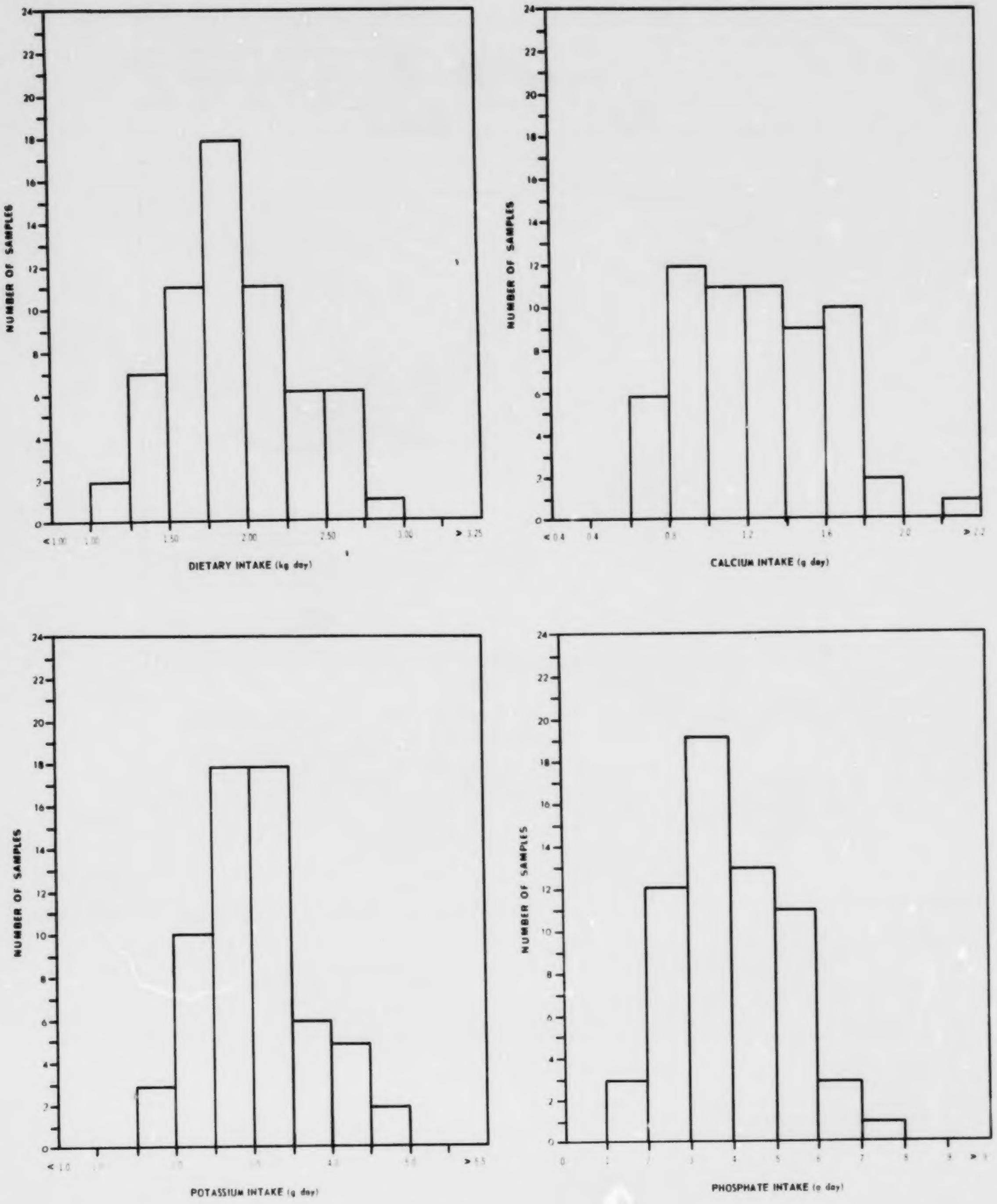


FIGURE 2.—DISTRIBUTION OF THE NUMBER OF SAMPLES VERSUS INTAKE

33



OF MATERIALS IN INSTITUTIONAL DIETS FOR OCTOBER–DECEMBER 1963

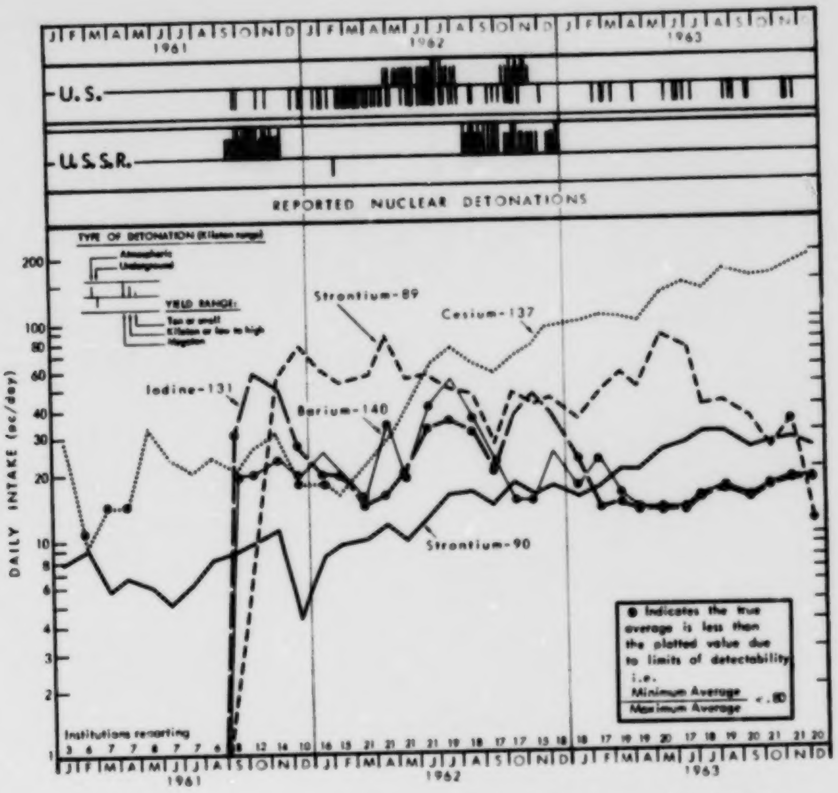


FIGURE 3.—FISSION PRODUCTS IN INSTITUTIONAL DIET SAMPLES—AVERAGE OF INSTITUTIONS

REFERENCES

(1) Anderson, E. C., and D. J. Nelson, Jr.: Surveillance for Radiological Contamination in Foods, *American Journal of Public Health, 52:* 1391–400 (September 1962).

(2) Chen, P. S., Jr., A. R. Terepka, and H. C. Hodge: The Pharmacology and Toxicology of the Bone Seekers *Annual Review of Pharmacology 1*:369–96 (1961).

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Previous coverage in *Radiological Health Data:*

Period	Issue
July–September 1962	*April 1963*
October–December 1963	*July 1963*
January–March 1963	*September 1963*
April–June 1963	*December 1963*
July–September 1963	*March 1964*

35

STRONTIUM-90 AND CALCIUM IN INFANT DIETS, 1963[1]

Joseph Rivera[2]

Since the rate of bone formation is high during the first year of life, it is particularly important to know the dietary intake of strontium-90 and calcium during this period so that reasonable estimates can be made of body burdens of strontium-90 in young children. The dietary estimates of strontium-90 intake are complicated since the foods eaten at this age are especially processed and may not have the same strontium-90 concentrations as the same type foods prepared for adult consumption.

For infants who are not breast fed, the diet during the first year of life consists chiefly of specially prepared formula milks, evaporated milk, and, starting at about three months old, specially prepared cereals, vegetables, fruits, and meats (*1*).

For the last quarter of 1963, in addition to sampling the milk components of infant diets at the three cities, non-milk components were also analyzed. The results are presented in table 1 together with estimates of the Sr^{90}/Ca ratio of the total infant diet during the first year of life.

From these data we calculate that about 85 percent of the total Ca intake was from formula and evaporated milks. Assuming this relative fraction to be constant with time, the Sr^{90}/Ca

Table 1.—STRONTIUM-90 AND CALCIUM IN INFANT DIETS DURING THEIR FIRST YEAR OF LIFE, OCTOBER-DECEMBER 1963 SAMPLING

Location and food category	Average consumption[a] (kg/yr)	Calcium		Strontium-90		Sr^{90}/Ca (pc/g)	
		Concentration (g/kg)	Intake (g/yr)	Concentration (pc/kg)	Intake (pc/yr)		
New York (sampled 11/63)							
Cereals	8	6.57	52.6	23.7	190	3.6	
Vegetables	23	0.35	8.1	17.0	391	48	[b] 10.7
Fruits	23	0.11	2.5	3.7	85	34	
Meats	17	0.15	2.6	2.4	41	16	
Formula milks	37	1.62	59.9	46.7	1,728	29	[c] 33
Evaporated milks	137	2.48	339.8	82.4	11,289	33	
Total diet	245	1.90	466	56.0	13,724		[d] 29
Chicago (sampled 10/63)							
Cereals	8	7.56	60.4	24.1	193	3.2	
Vegetables	23	0.17	3.9	4.7	108	28	[b] 6.1
Fruits	23	0.08	1.8	2.6	60	33	
Meats	17	0.20	3.4	3.9	66	19	
Formula milks	37	1.63	60.3	73.6	2,723	45	[c] 33
Evaporated milks	137	2.54	348.0	73.4	10,558	30	
Total diet	245	1.95	478	56.0	13,708		[d] 29
San Francisco (sampled 12/63)							
Cereals	8	[e] 5.61	44.9	21.8	174	3.9	
Vegetables	23	[d] 0.35	8.1	8.3	191	24	[b] 9.3
Fruits	23	0.04	0.9	1.9	44	49	
Meats	17	[f] 0.17	3.0	7.0	119	40	
Formula milks	37	1.20	44.4	29.6	1,095	25	[c] 12.7
Evaporated milks	137	2.40	328.8	26.7	3,658	11	
Total diet	245	1.96	430	21.6	5,281		[d] 12

[a] Data from HASL-88—see reference 1.
[b] Non-milk component.
[c] Milk component.
[d] Total diet.
[e] August 1961 sampling.
[f] Estimated from New York City and Chicago samples.

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[1] Originally published in Health and Safety Laboratory, AEC, *Fallout Quarterly Summary Report, HASL-144*: 274-7, Office of Technical Services, U.S. Department of Commerce, Washington, D.C. 20230 (April 1, 1964), price $4.00.

[2] Mr. Rivera is a physicist on the staff of Environmental Studies Division of the Health and Safety Laboratory, U.S. Atomic Energy Commission.

36

TABLE 2.—STRONTIUM-90 CONCENTRATIONS AND INTAKE OF INFANTS FROM MILK DURING 1963

Location and sampling date	Formula milk		Evaporated milk		Total intake from milk (pc/yr)
	Concentration (pc/kg)	Intake (pc/yr)	Concentration (pc/kg)	Intake (pc/yr)	
New York City					
February	[a] 22.7 ± 0.9	840	45.9 ± 2.3	6288	7128
May	28.2 ± 0.9	1043	35.0 ± 1.3	4795	5838
August	41.9 ± 0.1	1550	40.8 ± 1.1	5590	7140
November	46.7 ± 0.4	1728	82.4 ± 1.8	11289	13017
Average	—	1290	—	6991	8281
Chicago					
January	26.7 ± 0.7	988	46.5 ± 1.0	6371	7359
April	13.9 ± 0.6	514	41.7 ± 1.4	5713	6227
June	27.4 ± 0.9	1014	52.9 ± 1.4	7249	8261
October	73.6 ± 1.5	2723	73.4 ± 2.3	10558	13281
Average	—	1310	—	7472	8782
San Francisco					
March	32.3 ± 1.2	1195	10.1 ± 0.6	1384	2579
June	27.6 ± 0.7	1021	38.9 ± 1.1	5329	6350
September	23.2 ± 0.7	858	18.6 ± 0.9	2548	3406
December	29.6 ± 0.9	1095	26.7 ± 1.3	3658	4753
Average	—	1044	—	3230	4274

[a] Error terms are one standard deviation due to counting.

ratio of the total diet (T.D.) can be expressed as:

$$T.D. = 0.85\ M + 0.15\ N.M.$$

where M is the Sr^{90}/Ca ratio of the milk component of the diet and N.M. is the Sr^{90}/Ca ratio of the non-milk component of the diet. Dividing by M we have:

$$T.D./M = 0.85 + 0.15\ N.M./M$$

Using the data in table 1 it may be seen that at the end of 1963 the ratio N.M./M ranged from 0.2 to 0.7 and averaged roughly ¼ for New York and Chicago so that:

$$T.D. = (0.85 + 0.15 \times 1/4)\ M$$

$$T.D. = 0.9\ M$$

Table 2 summarizes the data collected during 1963 concerning strontium-90 in infant diets.

If the annual Sr-90 intakes from milk products listed in table 2 are divided by the average annual Ca intake from milk components of the diet (394 g/yr as calculated from table 1), then M is obtained. Multiplying this M by 0.9 we obtain estimates of the total diet Sr^{90}/Ca ratio. For average New York City, Chicago, and San Francisco infant diets during 1963, these estimates are 19, 20, and 10 pc/g Ca respectively.

If the diet-bone observed ratio for one year old children is 0.3 (2) then the expected Sr^{90}/Ca ratio of bones of one year old children who died in the first quarter of 1964 in New York City and Chicago should be between 6 and 7 pc/g Ca while bone specimens from children who lived in San Francisco prior to death can be expected to have Sr^{90}/Ca ratios of about 3 pc/g Ca.

During 1964, it is expected that the ratio N.M./M will become equal to or exceed unity. The reason for this is that cereal products and other non-milk foods produced during periods of relatively heavy fallout in 1963, will then begin to become available in retail markets. However, even if the ratio N.M./M increases tenfold from 0.25 to 2.5 the ratio T.D./M will only change from 0.9 to 1.2 so that the Sr^{90}/Ca ratio of milk products will continue to be a good approximation of the Sr^{90}/Ca ratio of the total diet of infants.

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(1) U.S. Atomic Energy Commission: *Health and Safety Laboratory, Fallout Program Quarterly Summary Report, HASL-88:* 230-8, Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (July 1, 1960), price $3.50.

(2) U.S. Atomic Energy Commission: *Health and Safety Laboratroy, Fallout Program Quarterly Summary Report, HASL-138:* 235-8, Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (July 1, 1963), price $3.50.

Previous coverage in *RHD:*

Period	Issue
August 1959 and January 1960	*October 1960*
1959-1961	*November 1962*
1959-1962	*August 1963*

Section III—Water

RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, JANUARY 1964

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been under surveillance by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this System has expanded to 130 stations as of May 1, 1964. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U. S. river basins for physical, chemical, biological and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the System provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be subjected. Data assembled through the System are published in an annual compilation (*1–7*).

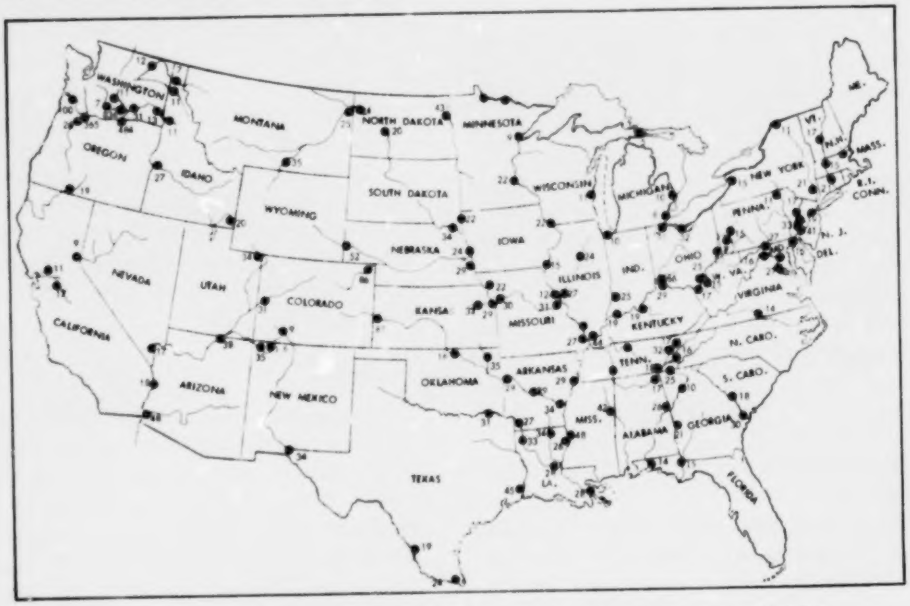
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LA.
WISCONSIN
ILLINOIS
MISS.
MICHIGAN
IND.
KENTUCKY
TENN.
ALABAMA
OHIO
W. VA.
VIRGINIA
N. CARO.
S. CARO.
GEORGIA
FLORIDA
PENNA.
NEW YORK
N. J.
DEL.
VT.
N.H.
MASS.
R.I.
CONN.
ME.

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATER, JANUARY 1964

Sampling Procedures

The participating agencies collect one-liter "grab" samples each week and ship them to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta activity determinations on suspended and dissolved solids and strontium-90 determinations on total solids are performed as frequently as deemed necessary.

Presently, gross alpha and beta determinations are made on monthly composites of the weekly samples received from all stations, except those located downstream from known potential sources of radioactive waste and those from all newly established System stations. Weekly alpha and beta measurements are scheduled routinely during the first year of operation at newly established stations.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

Analytical Methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*8*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counters.

Since the fourth quarter of 1958, strontium-90 analyses have been made on three-month composites of aliquots from weekly samples. Beginning in November 1962, two quarterly samples per year have been analyzed for strontium-90 at each sampling point except those stations immediately below nuclear installations. At these stations four determinations per year are performed. The method used for determining strontium-90 is a modification of a procedure described by Harley (*9*). The yttrium-90, together with a yttrium carrier, is precipitated at pH 8.5; the precipitate is washed, redissolved, and reprecipitated as yttrium oxalate and the latter is washed and counted in a low-background, anticoincidence, end-window proportional counter.

Results

Table 1 presents January 1964 results of alpha and beta analyses of U.S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first station listed being closest to the headwaters. These data are preliminary. Replicate analyses of some samples as well as some analyses incomplete at the time of this report will be included in the System's Annual Compilation of Data (*7*). The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter. When all samples have zero pc/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5 the mean is reported as <1 pc/liter. The most recent quarterly strontium-90 results appeared in the January 1964 *RHD* (*10*).

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the January 1964 average total beta activity in suspended-plus-dissolved solids in raw water collected at that station. Results for the years 1957-1962 have been summarized by Weaver *et al.* (*11*).

Discussion

The monthly dissolved beta activity averages exceeded 100 pc/liter only on the Columbia and Clinch Rivers. Of the six stations on the Columbia River, the four downstream from the Hanford Atomic Products Operations facility had averages of between 79 and 763 pc/liter. It can be observed that the concentration [illegible]minishes with distance downstream fro[illegible] facility.

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, JANUARY 1964

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River:						
Pittsbugh, Pa	6	9	15	0	0	0
Animas River:						
Cedar Hill, N. Mex	2	14	16	0	2	2
Apalachicola River:						
Chattahoochee, Fla	6	9	15	1	0	1
Arkansas River:						
Coolidge, Kansas	14	73	87	2	38	40
Ponca City, Okla	6	10	16	0	2	2
Fort Smith, Ark	6	23	29	0	0	0
Little Rock, Ark	9	20	29	1	1	2
Pendleton Ferry, Ark	11	23	34	1	0	1
Bear River:						
Preston, Idaho	1	19	20	0	0	0
Big Horn River:						
Hardin, Mont	4	31	35	0	7	7
Big Sioux River:						
Sioux Falls, S. Dak	0	22	22	0	0	0
Chattahoochee River:						
Atlanta, Ga	4	6	10	0	0	0
Columbus, Ga	13	8	21	1	0	1
Lanett, Ala	18	8	26	4	0	4
Chena Slough:						
Fairbanks, Alaska	1	3	4	0	0	0
Clearwater River:						
Lewiston, Idaho	4	7	11	0	0	0
Clinch River:						
Clinton, Tenn	3	14	17	0	<1	<1
Kingston, Tenn	15	311	326	0	<1	<1
Colorado River:						
Loma, Colo	9	22	31	1	9	10
Page, Ariz	1	37	38	1	6	7
Boulder City, Nev	4	13	17	0	3	3
Parker Dam, Calif-Ariz	2	16	18	0	6	6
Yuma, Ariz	0	48	48	0	2	2
Columbia River:						
Northport, Wash	2	10	12	0	1	1
Wenatchee, Wash	0	11	11	0	1	1
Pasco, Wash	73	763	836	0	<1	<1
McNary Dam, Ore	27	457	484	0	2	2
Bonneville, Ore	28	337	365	0	<1	<1
Clatskanie, Ore	21	79	100	0	0	0
Connecticut River:						
Wilder, Vt	5	12	17	0	0	0
Northfield, Mass	5	10	15	0	0	0
Enfield Dam, Conn	5	16	21	0	0	0
Cuyahoga River:						
Cleveland, Ohio	4	28	32	<1	0	<1
Delaware River:						
Martins Creek, Pa	5	12	17	0	0	0
Trenton, N. J	11	8	19	0	0	0
Philadelphia, Pa	20	13	33	0	0	0
Escambia River:						
Century, Fla	7	7	14	1	0	1
Great Lakes:						
Duluth, Minn	1	8	9	0	0	0
Sault Ste. Marie, Mich	1	4	5	0	0	0
Milwaukee, Wisc	5	6	11	0	0	0
Gary, Ind	4	6	10	0	0	0
Port Huron, Mich	2	8	10	0	0	0
Detroit, Mich	1	7	8	0	0	0
Buffalo, New York	3	12	15	0	1	1
Green River:						
Dutch John, Utah	2	32	34	0	2	2
Hudson River:						
Poughkeepsie, N. Y	6	15	21	0	0	0
Illinois River:						
Peoria, Ill	7	17	24	2	2	4
Grafton, Ill	84	40	124	2	0	2
Kanawha River: Winfield Dam, W. Va	6	9	15	0	0	0
Kansas River:						
De Soto, Kansas	3	29	32	0	1	1
Klamath River:						
Keno, Oreg	6	13	19	0	0	0
Little Miami River:						
Cincinnati, Ohio	28	38	66	1	1	2
Maumee River:						
Toledo, Ohio	5	27	32	0	0	0
Mississippi River:						
St. Paul, Minn	1	21	22	0	0	0
Dubuque, Iowa	2	20	22	0	3	3
Burlington, Iowa	1	14	15	0	1	1
E. St. Louis, Ill	5	22	27	0	0	0
Cape Girardeau, Mo	11	16	27	1	2	3
W. Memphis, Ark	12	17	29	1	1	2
Vicksburg, Miss	30	18	48	3	1	4
Delta, La	10	16	26	1	1	2
New Orleans, La	8	20	28	1	1	2
Missouri River:						
Williston, N. Dak	5	19	24	1	6	7
Bismarck, N. Dak	1	19	20	0	2	2
Yankton, S. Dak	10	24	34	2	2	4
Omaha, Nebr	4	20	24	0	2	2
St. Joseph, Mo	2	20	22	0	4	4
Kansas City, Kans	5	24	29	1	3	4
Missouri City, Mo	5	25	30	0	0	0
St. Louis, Mo	11	20	31	1	3	4
Monongahela River:						
Pittsburgh, Pa	2	5	7	0	0	0
North Platte River:						
Henry, Nebr	8	44	52	1	34	35
Ohio River:						
Addison, Ohio	14	11	25	1	0	1
Huntington, W. Va	8	9	17	0	0	0
Cincinnati, Ohio	19	10	29	2	0	2
Louisville, Ky	8	11	19	0	0	0
Evansville, Ind	8	11	19	0	0	0
Cairo, Ill	31	13	44	8	0	8
Toronto, Ohio	13	10	23	1	0	1
Ouachita River:						
Bastrop, La	8	26	34	0	2	2
Pend Oreille River:						
Albeni Falls Dam, Idaho	2	5	7	0	0	0
Platte River:						
Plattsmouth, Nebr	4	25	29	0	6	6
Potomac River:						
Williamsport, Md	14	13	27	0	0	0
Great Falls, Md	21	9	30	2	0	2
Washington, D.C	17	10	27	2	0	2
Rainy River:						
Baudette, Minn	4	45	49	0	0	0
International Falls, Minn	3	31	34	0	0	0
Red River, North:						
Grand Forks, N. Dak	2	41	43	0	1	1
Red River, South:						
Denison, Tex	1	30	31	0	0	0
Index, Ark	3	24	27	1	0	1
Bossier City, La	5	28	33	0	0	0
Alexandria, La	26	29	55	5	1	6
Rio Grande River:						
Alamosa, Colo	2	7	9	1	1	2
El Paso, Tex	7	27	34	1	4	5
Laredo, Tex	5	14	19	1	3	4
Brownsville, Tex	4	20	24	0	4	4
Roanoke River:						
John H. Kerr Resr/Dam, Va	4	10	14	0	0	0
Sabine River:						
Ruliff, Tex	21	24	45	1	0	1
Sacramento River:						
Courtland, Calif	4	7	11	0	1	1
St. Lawrence River:						
Massena, N. Y	1	10	11	0	0	0
San Joaquin River:						
Vernalis, Calif	4	13	17	0	3	3
San Juan River:						
Shiprock, N. Mex	8	27	35	1	11	12
Savannah River:						
North Augusta, S. C	7	11	18	1	0	1
Port Wentworth, Ga	7	23	30	1	0	<1
Schuylkill River:						
Philadelphia, Pa	32	9	41	1	0	1
Shenandoah River:						
Berryville, Va	9	7	16	0	0	0
Ship Creek:						
Anchorage, Alaska	1	3	4	0	0	0
Snake River:						
Ice Harbor Dam, Wash	1	12	13	0	3	3
Wawawai, Wash	20	11	31	3	3	6
Payette, Idaho	10	17	27	0	5	5
South Platte River:						
Julesburg, Colo	24	62	86	3	39	42
Spokane River:						
Post Falls, Idaho	3	8	11	0	0	0
Susquehanna River:						
Sayre, Pa	5	6	11	1	0	1
Conowingo, Md	6	9	15	1	0	1
Tennessee River:						
Lenoir City, Tenn	6	10	16	0	0	0
Chattanooga, Tenn	5	20	25	<1	0	<1
Bridgeport, Ala	5	12	17	0	0	0
Pickwick Landing, Tenn	4	14	18	0	0	0
Tombigbee River:						
Columbus, Miss	25	17	42	2	0	2
Truckee River:						
Farad, Calif	3	6	9	0	0	0
Verdigris River:						
Nowata, Okla	4	31	35	1	1	2
Wabash River:						
New Harmony, Ind	9	16	25	0	0	0
Willamette River:						
Portland, Oreg	17	9	26	1	0	1
Yakima River:						
Richland, Wash	1	6	7	0	2	2
Yellowstone River:						
Sidney, Mont	3	22	25	0	3	3
Maximum	73	763	836	5	39	42
Minimum	0	3	4	0	0	0

The dissolved alpha activity, which is associated with the dissolving of natural surface minerals by water, range in monthly averages to 39 pc/liter. Of all stations, three on different rivers had monthly average dissolved alpha activity greater than 10 pc/liter.

While there are no generally applicable standards for surface water, the radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (*12*). The Public Health Service Drinking Water Standards state that in the absence of strontium-90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentration does not exceed 1000 pc/liter (*13*).

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(*8*) American Public Health Association, American Water Works Association and Water Pollution Control Federation: *Standard Methods for the Examination of Water and Wastewater*, 11th Edition, New York (1960).

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[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pc/liter and 10 pc/liter for unidentified alpha emitters and strontium-90, respectively.

[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U.S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

Section IV—Other Data

MEDICAL X-RAY UNITS IN THE CITY OF BALTIMORE: FINDINGS OF THE 1963 PILOT SURVEY

Perry F. Prather, Robert E. Farber and Howard E. Chaney[1]

During the summer months of 1963, a survey was made of the X-ray units and installations in the offices of a selected group of physicians in the City of Baltimore, Maryland. Those selected were members of the Baltimore City Medical Society practicing in the center of the City.

The Survey was conducted as a joint, cooperative venture by the Maryland State Department of Health, the Baltimore City Health Department and the Public Health Service.

The Commissioner of Health of the City of Baltimore met with the Baltimore City Medical Society and explained the purpose of the survey, emphasizing that participation would be voluntary and that the individual findings would be reported to the participants. It was indicated that the data would be held in confidence and used only in a statistical summary in such a manner as to be individually unidentifiable. The approval and support of the Baltimore City Medical Society was given to the survey.

Following these initial steps, the Commissioner of Health of the City of Baltimore prepared and distributed a letter explaining the survey in detail to the constituent members of the Medical Society.

The principal purpose of the survey was to estimate the degree to which existing X-ray units employed by this segment of the medical profession met minimum standards established by:

1. The National Committee on Radiation Protection and Measurements as published in "Handbook 76" of the National Bureau of Standards (*1*).
2. "Suggested State Regulations for Control of Radiation" prepared by the Council of State Governments in cooperation with the United States Atomic Energy Commission and the Public Health Service (*2*).

(Subsequent to this undertaking, the Maryland State Board of Health and Mental Hygiene adopted regulations on September 27, 1963, to become effective January 1, 1964, according to the above standards.)

Additional objectives of the survey were to:

1. Obtain a basis for extending the estimate of the condition of the medical X-ray units in use in the City to those in the State.
2. Provide field experience in survey techniques for City Health Department personnel.
3. Develop a field survey form and report for machine owners.

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[1] Dr. Prather is Commissioner of Health, Maryland State Department of Health, Dr. Farber is Commissioner of Health, Baltimore City Health Department, and Mr. Chaney is Public Health Radiation Specialist, Maryland State Department of Health, 301 West Preston Street, Baltimore, Maryland.

Procedure

Two teams, each consisting of a representative of each participating agency mentioned above, were formed to conduct the field phase of the survey from July 1, 1963 to September 6, 1963.

During the period June 19, 1963 to July 1, 1963, the survey instruments and the techniques to be utilized were demonstrated by members of the State Health Department. Several surveys were made of X-ray units and their installations under the jurisdiction of the health departments. These first surveys were helpful in developing two smoothly functioning survey teams.

Starting with the core of metropolitan Baltimore, the teams surveyed physicians' offices within progressively larger circular areas. Prior to visiting the physicians' offices, Baltimore City Health Department personnel telephoned the offices to verify the possession of an X-ray unit and to arrange a mutually convenient date for the survey.

Approximately one day each week the group assembled to discuss the survey results, note the deficiencies, and prepare the reports to be forwarded to each X-ray machine owner participating in the project.

Survey Findings

The survey data have been summarized and are presented in the following series of tables and commentary.

It will be noted that combination radiographic-fluoroscopic units have been counted as two units. This was felt to be justifiable inasmuch as additional survey procedures, unique for each type unit, were necessary and constituted, at least in part, a separate study.

Efforts were made to visit as many units in as many installations (locations) as time would permit; hospital radiology departments were not included because they were felt to be in close agreement with existing standards (*1*). The miscellaneous group includes those types of practice for which an insignificant number of units were surveyed, making a separate notation unwarranted.

Any limitations of the data would stem primarily from the fact that medical X-ray machines used in general practice were concentrated upon, and machines in other types of practice were surveyed only as they occurred in the course of the study. Additional bias might be introduced by the fact that the X-ray machines surveyed in the center of the City might be significantly different from those found in the rest of the City or in the State.

TABLE 1.—NUMBER OF X-RAY UNITS SURVEYED

Type of Unit	Number
Radiographic [1]	108
Fluoroscopic [1]	74
Therapeutic	18
Chiropractic	2
Total	202

[1] Combination units counted in both groups.

TABLE 2.—X-RAY UNITS—BY TYPE OF MEDICAL PRACTICE

Types of practice	Total number
General practice	28
Internal medicine	32
Orthopedics	17
Radiology	15
Urology	9
Miscellaneous	28
Total	129

Radiographic X-ray Units

Table 3 presents the deficiencies noted during the survey. The survey revealed that 75.9 percent of the diagnostic X-ray units were found to be deficient in one or more aspects. Conversely, 24.1 percent were reported to have no deficiencies.

TABLE 3.—DEFICIENCIES NOTED FOR DIAGNOSTIC RADIOGRAPHIC UNITS

Deficiency	Number	Percent of units surveyed
None	26	24.1
Useful X-ray beam not confined to area of clinical interest	63	58.3
No beam centering device	58	51.9
Total filtration in primary X-ray beam less than 2.5 mm. aluminum equivalent	57	51.8
No cones or diaphragms	28	27.9
Additional primary shielding required	22	20.4
No protective position, such as shield or booth for operator	21	19.4
Operator dose-rate in excess of 1 roentgen per hour	8	7.4
Protective aprons and gloves not available or not used	3	2.8
Operation possible outside shielded area	2	1.9
No device to terminate exposure after pre-set time	1	0.9
No audible communication between patient and operator	1	0.9
Faulty electrical system	1	0.9

In 58.3 percent of the machines, the primary X-ray beam exceeded the area of clinical interest and extended beyond the film. These X-rays do not contribute to the production of a radiograph and result in unnecessary exposure of the patient. Proper cones or a variable diaphragm collimator properly used would reduce or eliminate this unnecessary exposure. Three units were found equipped with variable diaphragm collimators, but improper use negated their value.

Insufficient filtration was found in 51.8 percent of the units checked. Aluminum filters placed in the primary X-ray beam reduce the quantity of soft, low energy X-rays in the beam. The low energy X-rays, not able to penetrate to the film, serve only to expose the patient and contribute nothing to the radiograph.

In approximately 20 percent of the installations surveyed, there was insufficient shielding to protect persons outside of the X-ray room from the primary X-ray beam. In some instances, a simple rearrangement of equipment would suffice; in most others, the proper use of cones or collimators would reduce the area requiring primary shielding. The lack of a control booth, shield, protective apron, the physical arrangement of some installations, or the techniques employed placed the physician (or technician) in a location of high exposure. Although the work load in most cases was low enough so that the maximum permissible exposure was not exceeded, the dose to which these persons were exposed could easily be, and should be, further reduced.

Reportable deficiencies were found in 91.9 percent of the fluoroscopic units surveyed.

The recommendation of the National Committe on Radiation Protection (*1*) is that the X-ray tube target should be 18 inches from the table top or panel and shall not be less than 12 inches; although this recommendation has been in effect for two revisions of the Committee Report, 4.1 percent of the installations were found with this distance less than 12 inches.

Fluoroscopic Units

Table 4 presents the deficiencies noted in the fluoroscopic units surveyed.

The amount of aluminum equivalent filtration was found to be less than the recommended (*1*) 2.5 millimeters in 62.6 percent of the units examined.

TABLE 4.—DEFICIENCIES NOTED FOR FLUOROSCOPIC UNITS

Deficiency	Number	Percent of units surveyed
None	6	8.1
Diaphragm system permits X-ray beam to exceed area of viewing screen	58	78.4
No manually reset, cumulative timer to indicate predetermined time or dose	57	77.0
Total filtration in primary X-ray beam less than 2.5 mm. aluminum equivalent	47	62.6
Dose rate at panel/table top more than 10 roentgens per minute	29	39.7
Viewing screen can be turned out of X-ray beam	16	21.6
Excessive transmission of X-ray beam through viewing screen	13	17.5
Lead protective gloves and aprons not available or not used	5	6.8
Target-to-panel/table top distance less than 12 inches	3	4.1
Defective foot switch	1	1.4

In 78.4 percent of the units, the diaphragm system was found to be improperly adjusted. In these units, when the viewing screen was placed at 15 inches from the panel/table top, the diaphragm system, when fully open, would permit the primary X-ray beam to extend beyond one or more edges of the screen. Thus, the fluoroscopist could be exposed to the primary beam attenuated only by the patient.

In nearly 40 percent of the units surveyed, the dose-rate measured at the panel/table top exceeded the 10 roentgen per minute maximum permissible dose rate for routine fluoroscopy (*1*). Table 5 presents the distribution of the dose-rates found during the survey.

TABLE 5.—OUTPUT AT PANEL/TABLE TOP OF FLUOROSCOPIC UNITS

Output (roentgens/minute)	Percent of units	Cumulative percent
<5	30.9	30.9
5–10	29.4	60.3
10–15	22.1	82.4
15–20	10.3	92.7
20–25	1.4	94.1
25–30	1.4	95.5
>30	4.5	100.0

The viewing screen in 17.5 percent of the units provided inadequate attenuation; *i.e.*, the exposure dose-rate was in excess of 50 milliroentgens per hour.

To restrict the dose a patient receives, a manually reset cumulative timer is recommended as a necessary adjunct; 77 percent of the units were not so equipped.

Dark adaptation was not practiced by 10 percent of those physicians using fluoroscopes. The eye is capable of discerning fainter images if 10 minutes or more are allowed for dark adaptation. This procedure makes it possible to reduce the radiation needed to produce an acceptable image, thereby reducing the patient dose.

Therapeutic Units

Too few therapeutic units were surveyed to generalize the conditions which might be expected to be encountered over a larger geographical area. It should be noted, however, that although the Grenz ray[1] does not usually require additional structural shielding, the damage to tissue is similar to other X-ray damage but limited to the superficial layers. Eyes, thyroid, and testes are certainly to be considered superficially located; hence, would be susceptible to damage from Grenz rays.

Miscellaneous

During the survey, a number of other items were noted and are presented without comment below for information.

Summary and Comments

The special survey of 202 Baltimore physician-office X-ray units located in 129 installations disclosed that more than 75 percent of the units were deficient in one or more items considered to meet minimum standards.

Reception by the majority of the participating physicians was quite favorable; comments were volunteered by many relative to the need for such a survey. It was evident from many questions and remarks that while the radiograph serves as a valuable diagnostic aid, the physical attributes and the subtle hazards are often not familiar to many physicians.

Unsolicited letters and telephone calls from participating physicians and telephone calls from the X-ray service companies are indicative of efforts being expended to make the recommended corrections.

TABLE 6.—PERSONNEL MONITORING USED

Use	Number	Type	Number	Exposure (mr/wk)	Number
Never	90	Film badge	39	Less than 25	39
Present	24	Pocket dosimeter	1	25–100	1
Discontinued	16			More than 100	0

TABLE 7.—TYPES OF UNITS SURVEYED, EXCLUSIVE OF THERAPEUTIC UNITS

Types	Number
Portable	5
Fixed-one tube	40
Tilting table-one tube	28
Tilting table-two tubes	22
Upright fluoroscope	15

TABLE 8.—VOLTAGE INDICATOR UNITS

Units	Number
Kilovolts	95
Primary volts	2
Arbitrary units	10

TABLE 9.—TYPE OF RADIATION WARNING SIGNAL

Type of warning signal	Number
None	61
Control panel light	39
Outside room	5

TABLE 10—TIMING DEVICES USED

Type	Number
None	1
Mechanical	33
Electrical	76

Acknowledgements

The physical surveys were made by Daniel Ready, Public Health Radiation Specialist, Robert E. Corcoran, Public Health Radiation Specialist, and Joe K. Donaldson, Division of Radiological Health, Public Health Service, assigned to the State of Maryland, for the Maryland State Department of Health; by David T. Lewis, Chief of Industrial Hygiene Investigations, Winston Miller, Principal Sanitarian, and Ralph Pfannenstiel, Sanitarian, for the Baltimore City Health Department; and Carl R. Pearson and Michael R. Roberts, then on duty with the Public Health Service.

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(*2*) Council of State Governments: *Suggested State Regulations for Control of Radiation*, Division of State and Licensee Relations, U.S. Atomic Energy Commission, Washington, D.C. 20545 (September 1962).

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[1] Grenz rays are X-rays produced at voltages of 5 to 20 kv.

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 23 AEC contractor installations have appeared periodically in *RHD* since November 1960. Following are reports for Oak Ridge Area, Paducah Plant, and Portsmouth Area Gaseous Diffusion Plant. These three installations are grouped together because each operates a gaseous diffusion plant; therefore they have similar systems of environmental monitoring.

Releases of radioactive materials from these plants for the periods covered in the reports below may be compared with standards set forth in the Federal Register, Title 10, Part 20. The appropriate concentration standards are given in table 1.

TABLE 1.—CONCENTRATION STANDARDS[a] PERTAINING TO ENVIRONMENTAL MONITORING AT OAK RIDGE AREA, PADUCAH PLANT, AND PORTSMOUTH PLANT

Line No.	Radionuclide or mixture of unknown nuclides	Air (pc/m³)	Water (pc/liter)
1	If α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, Bk^{249} are not present[b]	100	—
2	Cerium-144	200	10,000
3	Cesium-137	500	20,000
4	Cobalt-60	300	30,000
5	Ruthenium-103-106	200	10,000
6	Strontium-90	10	100
7	Thorium-protactinium-234	1000	20,000
8	Uranium-natural	2	20,000
9	Zirconium-niobium-95	1000	60,000

[a] The concentration standards given here were taken from the Atomic Energy Commission's regulation 10CFR, Part 20 (Federal Register, November 17, 1960).

[b] "Not present" implies that the concentration of the nuclide is small compared with its appropriate MPC. According to Federal Register, Title 10, Part 20, August 9, 1961, a group of nuclides may be considered not present if the ratio of each nuclide to its appropriate MPC is equal to or less than $\frac{1}{10}$ and if the sum of these ratios for the group in question is equal to or less than $\frac{1}{4}$.

1. Oak Ridge Area, 1963

Union Carbide Nuclear Company
Oak Ridge, Tennessee

Oak Ridge Area is a complex made up of many installations, including K–25, X–10, and Y–12 areas, the Oak Ridge National Laboratory (ORNL), and the Oak Ridge Gaseous Diffusion Plant (ORGDP).

Radioactive waste materials arising from the operation of atomic energy installations in Oak Ridge Area are collected, treated, and disposed of according to their physical states. Solid wastes are buried in a Conasauga shale formation which has a marked ion exchange activity that enables it to fix radioactive materials. Liquid wastes which contain long-lived fission products are confined in storage tanks or are released to trenches and pits located in the Conasauga shale formation. Low level liquid wastes are discharged, after preliminary treatment, to the surface streams. Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of filters, scrubbers, and/or precipitators.

Air Monitoring

Atmospheric contamination by long-lived fission products and fallout occurring in the general environment of East Tennessee are monitored by two systems of monitoring stations. One system consists of seven stations which encircle the plant areas (figure 1) and provide data for evaluating the impact of all Oak Ridge operations on the immediate environment. A second system consists of seven stations encircling the Oak Ridge Area at distances of from 12 to 75 miles (figure 2). This system provides data to aid in evaluating local conditions and to assist in determining the spread or dispersal of contamination should a major incident occur. Sampling is carried out by passing air continuously through a filter paper. Average concentrations are presented in table 2.

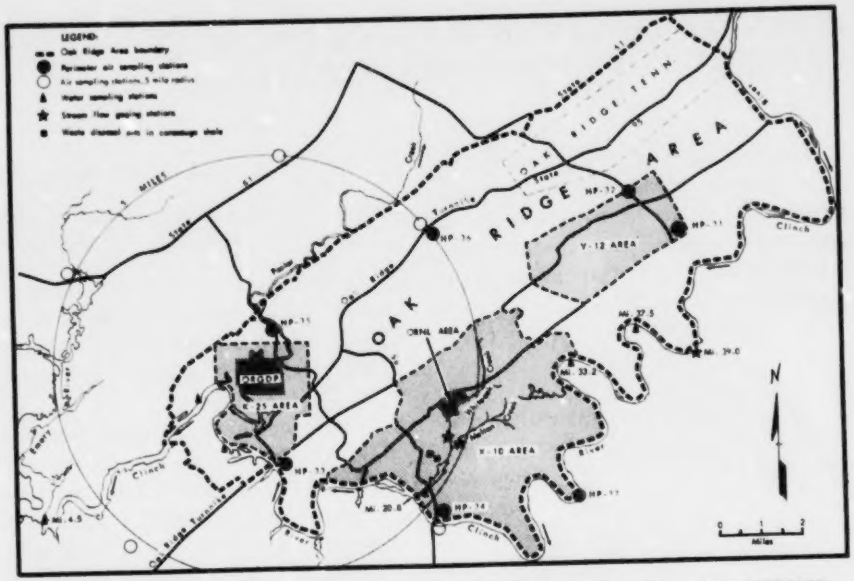
LEGEND:
Oak Ridge Area boundary
Perimeter air sampling stations
Air sampling stations, 5 mile radius
Water sampling stations
Stream flow gaging stations
5 MILES
OAK RIDGE AREA
OAK RIDGE TENN.
Y-12 AREA
ORNL AREA
X-10 AREA
ORGDP
K-25 AREA
HP-31
HP-32
HP-33
HP-34
HP-35
HP-36
HP-37
Clinch
Mi. 20.8
Mi. 33.2
Mi. 37.5
Mi. 39.0
Mi. 4.5
N
Miles

FIGURE 1.—OAK RIDGE AREA ENVIRONMENTAL SAMPLING LOCATIONS

TABLE 2.—LONG-LIVED GROSS BETA CONCENTRATIONS[1] IN AIR OAK RIDGE AREA, 1963

[Average concentrations in pc/m³]

Perimeter stations: (see figure 1)	First half 1963	Second half 1963	Remote stations: (see figure 2)	First half 1963	Second half 1963
HP-31	5.8	2.2	HP-51	5.7	2.3
HP-32	6.1	2.3	HP-52	6.6	2.7
HP-33	5.6	1.6	HP-53	6.5	2.4
HP-34	5.7	1.8	HP-54	6.7	2.7
HP-35	6.7	2.2	HP-55	6.1	2.3
HP-36	6.4	2.2	HP-56	6.3	2.4
HP-37	5.6	2.0	HP-57	5.9	2.2
Average	6.0	2.0	Average	6.3	2.4

[1] For MPC, see table 1, line 1.

Atmospheric contamination by uranium is determined by gross alpha measurements of continuous 8-hour air samples taken at five locations on a five-mile radius from the ORGDP (figure 1). The data are summarized in table 3.

Water Monitoring

Large volume, low level liquid wastes originating at ORNL are discharged, after some preliminary treatment, into the Tennessee River System by way of White Oak Creek and

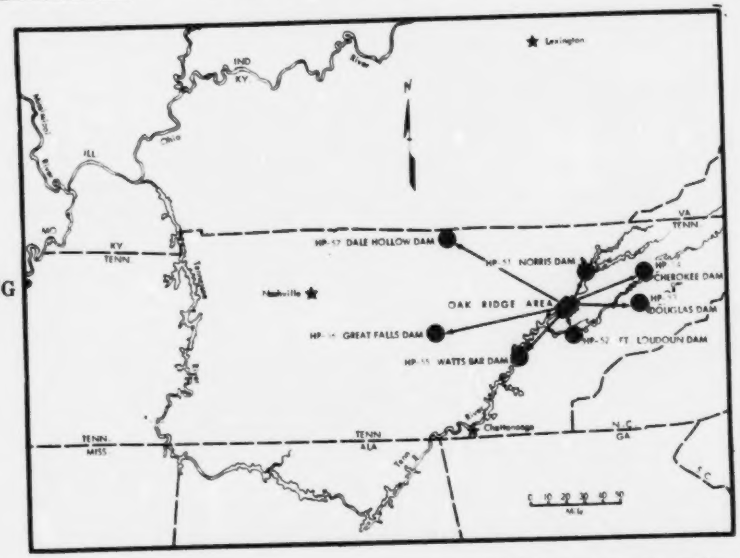
Lexington
IND
KY
Ohio
River
ILL
MO
KY
TENN
VA
TENN
HP-57 DALE HOLLOW DAM
HP-51 NORRIS DAM
CHEROKEE DAM
DOUGLAS DAM
OAK RIDGE AREA
Nashville
HP-56 GREAT FALLS DAM
HP-52 FT. LOUDOUN DAM
HP-55 WATTS BAR DAM
Chattanooga
TENN
MISS
TENN
ALA
N.C.
GA
S.C.
N
Miles

FIGURE 2.—REMOTE AIR MONITORING STATIONS, OAK RIDGE AREA

47

Table 3.—LONG-LIVED ALPHA ACTIVITY IN AIR[1] FIVE MILES FROM ORGDP

[Average concentrations in pc/m³]

Direction from plant	First half 1963	Second half 1963
North	0.17	0.25
East	0.17	0.50
South	0.23	—
West	0.35	0.25
Average	0.22	0.40

[1] Interpreted as uranium (natural).

the Clinch River. Liquid wastes originating at the ORGDP and the Y-12 Plant are discharged to Poplar Creek and thence to the Clinch River. Releases are controlled so that resulting average concentrations in the Clinch River comply with the maximum permissible levels for populations in the neighborhood of a controlled area as recommended by the National Committee on Radiation Protection (NCRP). The concentration of radioactivity leaving White Oak Creek is measured, and concentration values for the Clinch River are calculated on the basis of the dilution provided by the river.

Water samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tennessee. Stream gauging operations are carried on continuously by the U.S. Geological Survey to obtain dilution factors for calculating the probable concentrations of wastes in the river.

Samples are analyzed for the long-lived beta emitters, for uranium, and for the transuranic alpha emitters.

Analyses are made of the effluent for the long-lived radionuclides only, since cooling time and hold-up time in the waste effluent system is such that no short-lived radionuclides are present. The averages are given in tables 4 and 5.

Table 4.—CONCENTRATIONS OF MAJOR RADIONUCLIDES IN THE CLINCH RIVER

[Average concentrations in pc/liter]

Radionuclide	First half 1963			Second half 1963		
	Location on Clinch River[a]			Location on Clinch River[a]		
	Mi. 41.5 (Upstream)	Mi. 20.8[b] (Outfall)	Mi. 4.5 (Downstream)	Mi. 41.5 (Upstream)	Mi. 20.8[b] (Outfall)	Mi. 4.5 (Downstream)
Sr^{90}	1.0	1.4	2.1	1.5	1.4	3.6
Ce^{144}	2.7	0.2	3.8	1.3	0.1	1.6
Cs^{137}	0.1	0.3	2.9	0.4	1.3	1.6
$Ru^{103,106}$	13.5	77	130	5.0	28	34
Co^{60}	[c] ND	3.1	7.2	0.2	2.1	2.3
Zr^{95}-Nb^{95}	4.7	0.3	7.2	0.5	0.4	0.7
Gross beta	22	230	150	8.9	86	44

[a] The location on Clinch River is given in terms of the distance upstream from the Tennessee River. See figure 1.

[b] The concentrations at mi. 20.8 are not measured directly but the values are calculated on the basis of levels of waste released and the dilution afforded by the river.

[c] ND—None detected.

Table 5.—URANIUM CONCENTRATIONS IN THE CLINCH RIVER, OAK RIDGE AREA

[Average concentrations in pc/liter]

Sampling location	First half 1963		Second half 1963	
	No. of samples	Uranium concentration	No. of samples	Uranium concentration
Upstream from ORGDP	24	2	24	8
Downstream from ORGDP	25	2	24	2

Gamma Measurements

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge Area. Measurements are taken with a Geiger-Mueller tube at a distance of 3 feet above ground, and the results are shown in table 6 in terms of mr/hr.

TABLE 6.—EXTERNAL GAMMA RADIATION LEVELS, OAK RIDGE AREA

[Average dose rates in mr/hr]

Location	First half 1963	Second half 1963
Solway Gate	0.032	0.026
Y-12 East Portal	0.026	0.023
Newcomb Road	0.028	0.022
Gallaher Gate	0.035	0.028
White Wing Gate	0.017	0.015
Average	0.028	0.023

Previous coverage in *Radiological Health Data:*

Period	Issue
1959 and first quarter 1960	*December 1960*
Second and third quarters 1960	*March 1961*
Fourth quarter 1960	*July 1961*
First and second quarters 1961	*January 1962*
Third and fourth quarters 1961	*September 1962*
1962	*September 1963*

2. Paducah Plant, 1963

Union Carbide Nuclear Company
Paducah, Kentucky

The Paducah Plant is a Government-owned gaseous diffusion plant operated by Union Carbide Nuclear Company for the Atomic Energy Commission. The gaseous diffusion plant and the associated uranium hexafluoride manufacturing plant and uranium metal foundry process large quantities of relatively pure uranium compounds. The major sources of radiation from such materials are thorium-protactinium-234, and other beta-emitting daughters of uranium-238, concentrated in the ash produced during the fluorination process. Since the element uranium can be a physiological hazard only if it enters the body, the chemical toxicity of the uranium materials processed at the Paducah Plant overshadows any radiation danger from this element.

The environmental monitoring program consists of a continuing system for sampling air in four stations around the plant perimeter fence (not shown) and eight off-site stations; and for sampling water at one location in Big Bayou Creek, and five locations on the Ohio River as shown in figure 3.

Air

During 1963, air samples were collected continuously at each of the four air sampling stations at the plant perimeter fence and at four air sampling stations about one mile outside the fence. On July 1, 1963, four additional stations about five miles from the perimeter began operation. Samples are collected during a sampling period approximating a 168-hour week using a membrane filter. Uranium and beta activities in air for 1963 are summarized in table 7.

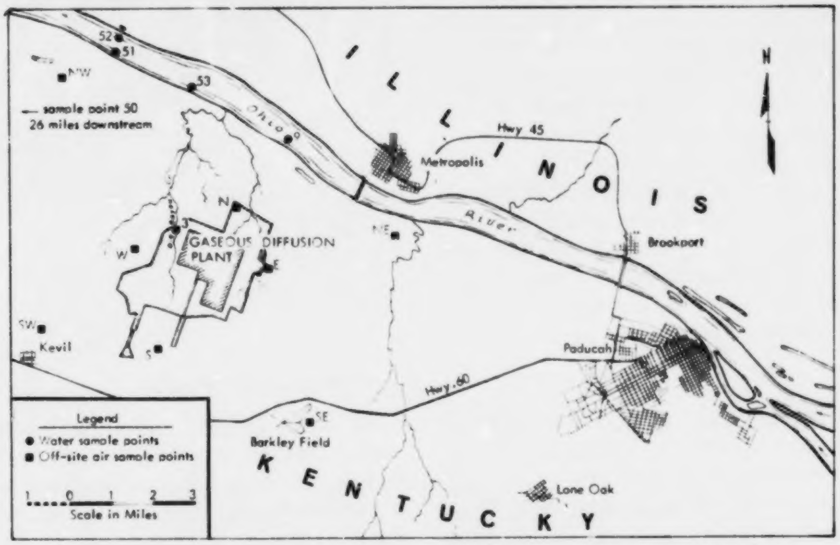
52
51
NW
53
— sample point 50
26 miles downstream
Ohio
River
I L L I N O I S
Hwy 45
Metropolis
N
N
3
W
GASEOUS DIFFUSION PLANT
E
NE
Brookport
SW
Kevil
S
Paducah
Hwy. 60
SE
Barkley Field
K E N T U C K Y
Lone Oak
Legend
● Water sample points
■ Off-site air sample points
1 0 1 2 3
Scale in Miles

FIGURE 3.—WATER SAMPLING LOCATIONS, PADUCAH GASEOUS DIFFUSION PLANT

TABLE 7.—AIRBORNE RADIOACTIVITY IN THE PADUCAH PLANT ENVIRONMENT, 1963

[Average concentrations in pc/m³]

Sampling location	Uranium alpha			Total beta [1]		
	1st half	2nd half	Year	1st half	2nd half	Year
Plant perimeter						
N	0.06	0.050	0.05	8.2	6.4	7.2
E	0.03	0.046	0.04	7.3	4.0	5.4
S	0.03	0.029	0.03	6.8	2.7	4.5
W	0.04	0.027	0.03	6.8	2.7	4.5
One mile outside perimeter						
N	0.02	0.029	0.03	7.3	2.7	4.5
E	0.03	0.027	0.03	7.3	2.3	4.5
S	0.03	0.035	0.03	6.7	2.3	4.5
W	0.02	0.027	0.03	7.3	2.7	4.5
SE	—	0.037	—	—	2.3	—
Five miles outside perimeter						
SW	—	0.042	—	—	2.3	—
NW	—	0.091	—	—	2.3	—
NE	—	0.077	—	—	2.3	—
SE	—	0.053	—	—	2.3	—

[1] Interpreted as thorium-protactinium-234.

Water

Uranium and beta analyses of the weekly continuous samples from Big Bayou Creek, and monthly grab samples from upstream and downstream locations on the Ohio River are presented in table 8.

TABLE 8.—RADIOACTIVITY IN WATER, PADUCAH PLANT, 1963

[Concentrations in pc/liter]

Sampling location	Uranium			Beta [1]		
	First half	Second half	Year	First half	Second half	Year
Big Bayou Creek 3	43	54	72	600	800	700
Ohio River (upstream) 9	<1	<1	<1	100	600	300
Composite of 50, 51, 52, and 53 (downstream)	<1	<2	<1	100	700	400

[1] Interpreted as thorium-protactinium-234.

Recent coverage in *Radiological Health Data:*

Period	Issue
1959 and first quarter 1960	*December 1960*
Second and third quarters 1960	*March 1961*
Fourth quarter 1960	*July 1961*
First and second quarters 1961	*January 1962*
Third and fourth quarters 1961	*August 1962*
1962	*September 1963*

3. Portsmouth Area Gaseous Diffusion Plant, 1963

Goodyear Atomic Corporation
Portsmouth, Ohio

The separation of uranium isotopes by the gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium-234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. Since natural uranium is an alpha emitter and thorium-234 is a beta-gamma emitter, environmental monitoring is conducted for evidence of alpha and beta-gamma emitters to test the effectiveness of plant controls.

Air samples are collected monthly at 21 sites located from 1 to 6 miles from the plant as shown in figure 4. Monthly water samples are collected at 14 stations within 5 miles of the plant.

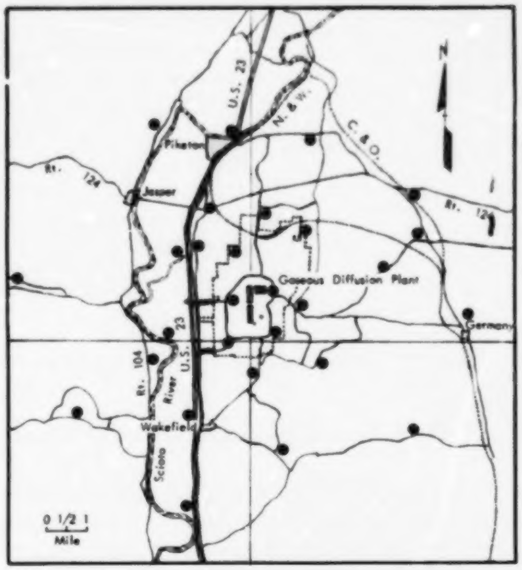

FIGURE 4.—AIR SAMPLING LOCATIONS, PORTSMOUTH GASEOUS DIFFUSION PLANT

Average alpha and beta-gamma concentrations in air and water are summarized in table 9. The external gamma levels are measured at the air sampling locations shown in figure 4 and the results included in table 9.

TABLE 9.—ENVIRONMENTAL RADIOACTIVITY, PORTSMOUTH PLANT

Measurement	Unit	January—June 1963				July—December 1963			
		No. of samples	Maximum	Minimum	Average	No. of samples	Maximum	Minimum	Average
Air (alpha concentration)	pc/m³	125	0.2	0.1	0.1	126	3.6	0.1	0.14
Air (beta-gamma concentration)	pc/m³	125	57.8	0.9	10.7	126	21.4	0.1	4.8
Water (alpha concentration)	pc/liter	79	675	0.5	27.2	70	285	0.5	20.9
Water (beta-gamma concentration)	pc/liter	79	986	14	38.9	70	720	14	37.1
External beta-gamma [a]	mrad/hr	125	0.122	0.014	0.054	126	0.127	0.012	0.056

[a] Measurements were made with open shield Geiger-Mueller tube one foot above ground. The three-foot rate (not shown) was experimentally determined to average two-thirds of the one-foot rate.

Previous coverage in *Radiological Health Data*:

Period	Issue
1959 and first quarter 1960	*November 1960*
Second and third quarters 1960	*March 1961*
Fourth quarter 1960	*August 1961*
First and second quarters 1961	*February 1962*
Third and fourth quarters 1961	*September 1962*
1962	*May 1963*

Correction for October 1962 Issue

The Atomic Energy Commission has recently advised *Radiological Health Data* of an error which appears in the October 1962 issue, page 422, table 12 entitled, "Air Monitoring Following the May 19, 1962 Event, NTS." Opposite Currant, the value for iodine-131 should read 5.6 pc/m³ rather than 516 pc/m³ as previously reported.

REPORTED NUCLEAR DETONATIONS, JUNE 1964

Three low-yield underground nuclear tests at the Nevada Test Site during June 1964 were announced by the Atomic Energy Commission. These tests, conducted on June 11th, 25th and 30th were assigned arbitrary *Radiological Health Data* reference numbers 158, 159, and 160, respectively. Tests 158 and 160 were part of the Plowshare Program to develop peaceful uses for nuclear explosives, being specifically related to excavation applications.

RADIOLOGICAL HEALTH DATA

VOLUME V, NUMBER 8
AUGUST 1964

TABLE OF CONTENTS

Page

SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation 351
  1. Radiation Surveillance Network, April 1964, PHS 351
  2. Canadian Air Monitoring Program, April 1964 355
  3. Mexican Air Monitoring Program, April 1964 357
  4. Pan American Air Sampling Program, April 1964, PAHO and PHS 358
  5. Gross Beta Activity in Air, North America, April 1964 358
Fission Product Gamma Activity in Air—80th Meridian Network, March and April 1964, W. R. Collins, Jr. 360
Monthly Deposition of Various Radionuclides 363
  1. Fallout in the United States and Other Areas, July-December 1963 363
  2. Fallout Measurements in Canada, January-March 1964 365

SECTION II.—MILK AND FOOD

Milk Surveillance 367
  1. Pasteurized Milk Network, April 1964, PHS 367
  2. Indiana Milk Network, April 1964 371
  3. New York Milk Network, February 1964 372
  4. Canadian Milk Network, April 1964 373
Moving Annual Average Radionuclide Concentrations in Pasteurized Milk, May 1963—April 1964, PHS 375
Quality Control Cross-Check Analyses of Gamma Emitters in Milk, Division of Radiological Health, April-October 1963, M. Rosenstein, K. H. Falter and A. S. Goldin 377

SECTION III.—WATER

Radioactivity in Surface Waters of the United States, February 1964, PHS 383
Radioactivity in Washington Surface Water, July 1962-June 1963, R. R. Mooney and P. W. Hildebrandt 386
Trends of Strontium-90 Levels in Surface Waters of the United States, 1959-1963, E. P. Floyd and L. Weaver 390

SECTION IV.—OTHER DATA

Radiological Survey of the Lower Columbia River in Oregon, January 1962-July 1963, G. L. Toombs and J. G. Bailey 395
Environmental Levels of Radioactivity at Atomic Energy Commission Installations 400
  1. Argonne National Laboratory, 1963 401
  2. Savannah River Plant, 1963 403
Nevada Test Site—Off-Site Surveillance of Accidental Releases, October 1962—March 1964, AEC 406
Reported Nuclear Detonations, July 1964 409

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

Section I—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess human radiation exposure from fallout, it is widely used as the basis of alerting systems for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form and are also shown by beta concentration isograms in figure 5.

1. Radiation Surveillance Network, April 1964

Division of Radiological Health, Public Health Service

Surveillance of atmospheric radioactivity in the United States in conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health which gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The alerting function of the Network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to eliminate interference from naturally-occurring radon daughters. The Network station operators regularly report their field estimates to the Radiation Surveillance Center, Division of Radiological Health, Washington, D. C. These field estimates are reported elsewhere on a monthly basis (*1*). When unusually high air levels are reported, appropriate Federal and State officials are notified.

Air

Airborne particulates are collected continuously on a carbon-loaded cellulose dust filter 4-inches in diameter. A volume of about 1800 cubic meters of air is drawn through the filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, and the gross beta activity measured using a thin-window, gas-flow proportional

53

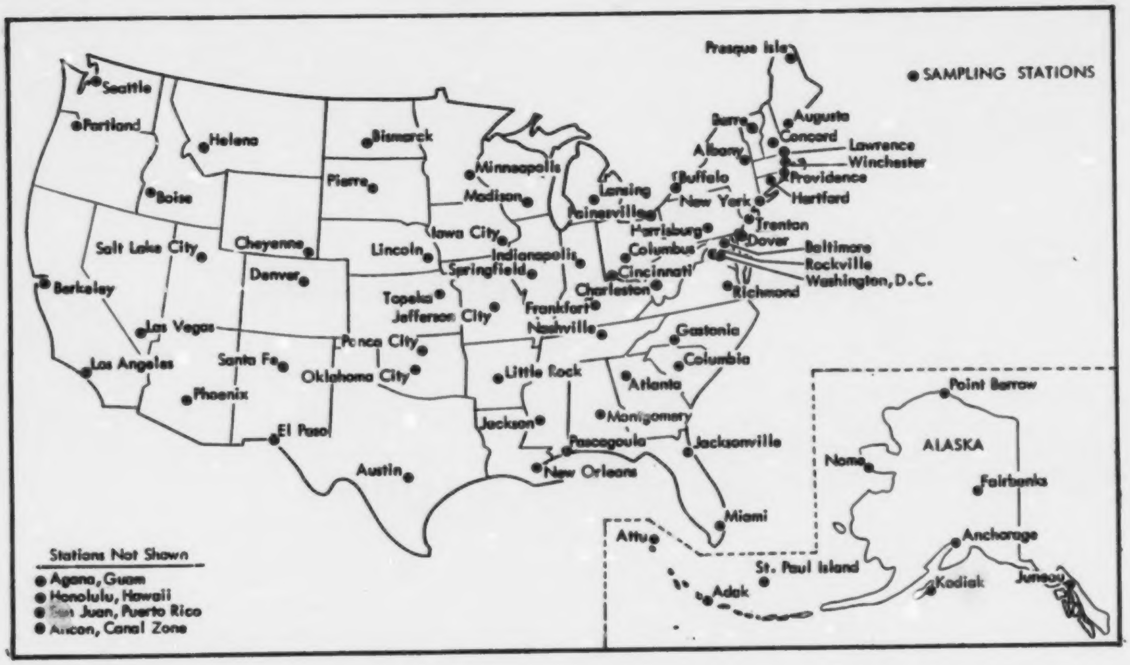
Presque Isle
SAMPLING STATIONS
Seattle
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Lansing
Painesville
Buffalo
Albany
Barre
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
New York
Trenton
Dover
Baltimore
Rockville
Washington, D.C.
Richmond
Harrisburg
Columbus
Cincinnati
Charleston
Salt Lake City
Cheyenne
Denver
Lincoln
Iowa City
Indianapolis
Springfield
Topeka
Jefferson City
Frankfort
Nashville
Gastonia
Columbia
Berkeley
Las Vegas
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Little Rock
Atlanta
Phoenix
El Paso
Jackson
Montgomery
Pascagoula
Jacksonville
Austin
New Orleans
Miami
Point Barrow
ALASKA
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
Agana, Guam
Honolulu, Hawaii
San Juan, Puerto Rico
Ancon, Canal Zone

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, APRIL 1964

counter, calibrated with a 38,700–pc Sr^{90}–Y^{90} standard.[1] Each filter is counted at least 3 days after the end of the sampling period and again 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. By using the two counts and the Way-Wigner formula (*2*), the age of fission products is estimated,[2] and the activity extrapolated to the time of collection.[3] The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*1*).

The Network's highest activity during April was observed on the Cheyenne, Wyoming April 23rd sample. The twenty samples with the highest activities during April are listed in table 1, giving the gross beta concentration and estimated age for each.

The April 1964 average gross beta concentration in air for each station is given in table 2. The Network average for April (1.56 pc/m^3) showed a slight decrease over the March aver-

TABLE 1.—GROSS BETA ACTIVITY AND AGE OF THE TWENTY INDIVIDUAL RSN AIR FILTERS HAVING HIGHEST ACTIVITIES DURING APRIL 1964

Station		Date April	Concentration (pc/m^3)	Age (days)
Colo:	Denver	23	5.12	>100
Miss:	Jackson	28	5.58	>100
Nev:	Las Vegas	11	7.29	>100
		12	5.64	>100
		13	5.49	>100
		27	5.63	>100
		29	5.86	>100
N. Mex:	Santa Fe	12	5.92	>100
		13	5.19	>100
Ore:	Portland	29	5.03	>100
Tex:	Austin	6	5.02	>100
		15	5.41	>100
		27	7.44	>100
		28	5.16	>100
		29	5.42	>100
Wyo:	Cheyenne	23	7.76	>100
		24	5.23	>100
		25	5.35	>100
		26	5.39	>100
		28	5.06	>100

---

[1] The Sr^{90}–Y^{90} source currently used as a standard was used from April 1962 to August 1963 as 40,000 pc total activity. Beginning with September 1963 data, the nominal activity of the standard was adjusted for decay (about 2½ percent per year) to 38,700 pc.

[2] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value and cannot be used for estimating date of formation.

[3] The Way-Wigner formula is $AT^{1.2}=C$, where A is the activity, T is the time (in any time unit) after fission product formation, and C is a constant equal to the activity at $T=1$.

TABLE 2.—GROSS BETA ACTIVITY IN AIR AND PRECIPITATION, APRIL 1964

Station location		Air surveillance					Precipitation measurements	
		Number of samples	Gross beta activity (pc/m³)			Last profile in *kHD*	Average concentration (pc/liter) [b]	Total deposition [b] (nc/m²)
			Maximum	Minimum	Average [a]			
Alabama:	Montgomery	22	3.54	0.29	1.80	Aug 64	300	118
Alaska:	Adak	26	2.44	<0.10	0.93	Nov 63	[c]	
	Anchorage	30	2.01	0.16	0.75	Jul 64	510	5.3
	Attu	1	0.13	0.13	0.13	Dec 63		
	Fairbanks	26	1.82	0.14	0.87	Aug 64	310	5.6
	Juneau	26	2.12	<0.10	0.57	Sep 63	290	61.2
	Kodiak	18	2.63	<0.10	0.70	Oct 63		
	Nome	14	0.77	<0.10	0.43	Feb 64		
	Point Barrow	30	1.08	0.33	0.66	Jan 64		
	St. Paul Island	29	2.14	0.11	0.85	Mar 64		
Ariz:	Phoenix	30	4.83	1.31	2.59	Sep 63	[d]—	
Ark:	Little Rock	28	4.37	1.03	2.15	Sep 63	320	87.3
Calif:	Berkeley	22	2.26	0.27	1.08	Oct 63	300	2.8
	Los Angeles	22	2.78	0.71	1.81	Feb 64	1,360	22.0
Canal Zone:	Ancon	16	1.61	<0.10	0.67	Apr 64	—	—
Colo:	Denver	25	5.12	0.34	2.38	Nov 63		
Conn:	Hartford	30	2.65	0.17	1.40	Oct 63	600	46.5
Del:	Dover	21	2.68	0.20	1.71	Aug 64	—	—
D. C:	Washington	30	3.21	0.14	1.58	Apr 64	290	106.0
Fla:	Jacksonville	30	4.16	0.79	2.23	Oct 63	210	10.9
	Miami	30	4.06	0.44	1.80	Feb 64	370	43.9
Ga:	Atlanta	0				Jul 64	—	—
Guam:	Agana	30	2.66	<0.10	0.60	Apr 64		
Hawaii:	Honolulu	30	1.76	0.34	0.93	Feb 64	500	13.5
Idaho:	Boise	26	2.84	0.50	1.47	Dec 63	510	10.4
Ill:	Springfield	27	2.79	0.30	1.61	Mar 64	910	50.3
Ind:	Indianapolis	26	3.35	0.58	1.70	Jul 64	810	129.0
Iowa:	Iowa City	28	2.84	0.33	1.48	Jan 64	540	46.9
Kans:	Topeka	21	3.27	0.63	1.61	Jul 64	640	94.9
Ky:	Frankfort	28	3.02	0.64	1.92	Feb 64	680	44.0
La:	New Orleans	29	2.54	0.40	1.56	Mar 64	250	67.7
Maine:	Augusta	29	3.11	0.17	1.67	Mar 64	460	46.2
	Presque Isle	29	2.25	<0.10	1.38	Nov 63	800	9.3
Md:	Baltimore	21	2.46	<0.10	1.25	Nov 63	1,060	74.2
	Rockville	5	2.14	<0.10	1.60	Mar 64		
Mass:	Lawrence	29	2.75	0.16	1.41	Aug 64	1,250	117.0
	Winchester	29	2.36	0.22	1.28	Apr 64	710	61.3
Mich:	Lansing	28	3.82	0.13	1.89	Feb 64	760	80.4
Minn:	Minneapolis	29	3.39	0.11	1.43	Mar 64	660	45.1
Miss:	Jackson	26	5.58	0.80	2.93	Apr 64	400	103.0
	Pascagoula					Dec 63	—	—
Mo:	Jefferson City	30	2.38	0.47	1.46	Jul 64	450	56.0
Mont:	Helena	28	2.78	<0.10	1.22	Nov 63	820	17.9
Nebr:	Lincoln	16	4.87	0.33	1.61	Apr 64	—	—
Nev:	Las Vegas	23	7.29	0.56	2.90	Aug 64	—	—
N. H:	Concord	18	2.96	0.18	1.72	Feb 64	—	—
N. J:	Trenton	30	3.03	0.18	1.43	Apr 64	940	29.5
N. Mex:	Santa Fe	28	5.92	0.64	2.38	Dec 63	740	24.8
N. Y:	Albany	22	2.03	0.23	1.18	Jul 64	340	15.6
	Buffalo	10	2.35	0.35	1.64	Nov 63	—	—
	New York	30	2.81	0.27	1.45	Dec 63	—	—
N. C:	Gastonia	30	3.60	<0.10	1.88	Jan 64	290	28.8
N. Dak:	Bismarck	28	3.16	0.16	1.64	Feb 64	760	59.3
Ohio:	Cincinnati	22	2.89	0.67	1.66	Aug 64	—	—
	Columbus	30	4.10	0.27	1.73	Apr 64	880	142
	Painesville	30	4.11	0.50	2.13	Oct 63	1,260	113
Okla:	Oklahoma	27	3.80	0.12	2.08	Apr 64	<200	<2.0
	Ponca City	27	2.13	<0.10	1.07	Oct 63	550	20.2
Ore:	Portland	29	5.03	0.45	1.96	Oct 63	330	14.6
Pa:	Harrisburg	29	1.91	0.11	0.80	Jul 64	580	44.7
P. R:	San Juan	29	2.01	0.53	1.07	Mar 64	270	17.1
R. I:	Providence	27	3.15	0.40	1.78	Jan 64	430	22.7
S. C:	Columbia	29	3.38	0.31	1.83	Dec 63	440	43.7
S. Dak:	Pierre	30	2.85	0.22	1.47	Sep 63	340	38.8
Tenn:	Nashville	26	3.84	0.18	2.04	Jan 64	540	61.9
Tex:	Austin	29	7.44	0.60	2.76	Aug 64	370	13.2
	El Paso	29	4.19	0.94	2.53	Jan 64	2,800	3.0
Utah:	Salt Lake City	30	3.59	0.26	1.85	Aug 63	660	57.1
Vt:	Barre	29	3.65	<0.10	1.73	Sep 63	290	21.7
Va:	Richmond	27	2.22	0.25	1.21	Sep 63	680	49.6
Wash:	Seattle	30	1.59	0.16	0.70	Jul 64	680	15.5
W. Va:	Charleston	29	4.02	0.43	1.87	Dec 63	1,190	90.3
Wisc:	Madison	29	4.00	0.28	1.70	Sep 63	450	42.8
Wyo:	Cheyenne	29	7.76	0.16	2.95	Aug 64	600	14.0
Network summary		1865	7.76	<0.10	1.56			

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[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed before the average.

[b] The minimum concentration reported for a single sample is 200 pc/liter. If the individual sample has a concentration of <200 pc/liter, the deposition for that sample is calculated by $D=\frac{C\times P}{1000}=<0.2$: in nc/m² (see text). A less-than sign (<) is used with the monthly total deposition whenever the sum of the individual less-than values represents more than 10 percent of the total. The monthly average concentration is then calculated as described in text, retaining the less-than sign when used with the total deposition.

[c] Blank space indicates no sample collected.

[d] Dash indicates no evaporated sample received.

55

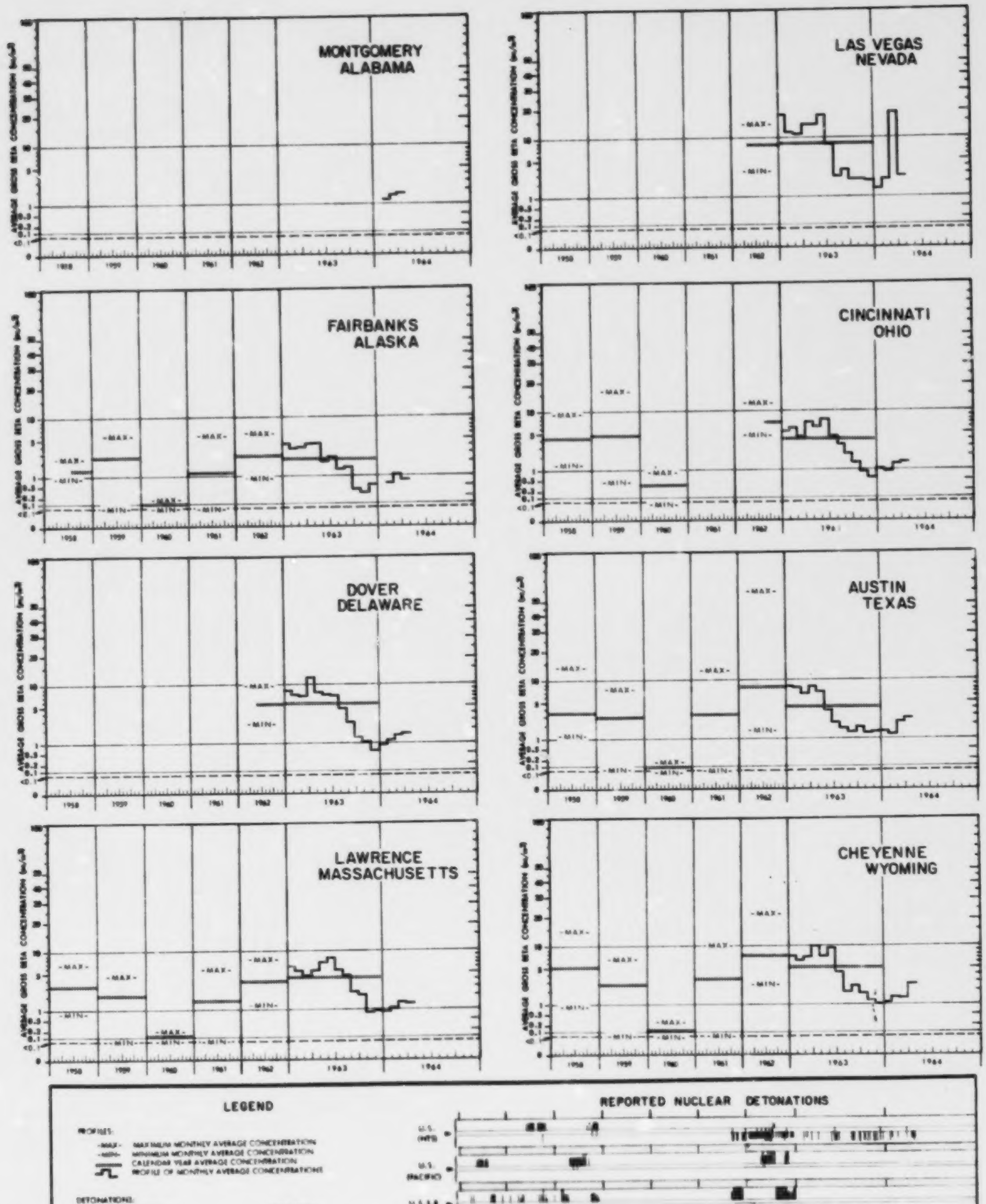

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR—RADIATION SURVEILLANCE NETWORK, 1958—APRIL 1964

age (1.60 pc/m³). Table 1, however, gives evidence that the activity due to the "spring rise" (activity injected from stratosphere during the spring months) showed an increase in April over that in March. The twenty highest samples in April ranged from 5.02 to 7.76 pc/m³—all having an age of >100 days. In March, the twenty highest samples ranged from 3.80 to 473 pc/m³. If the samples showing fresh fission products during March were disregarded, the highest 20 samples would have ranged between 3.80 and 5.21. Therefore, the range of old fission products in April appears to be distinctly higher than the corresponding range in March.

Time profiles of gross beta activity in air for eight RSN stations are shown in figure 2.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D=\frac{CP}{1000}$$

where D is the deposition in nc/m², C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, $\overline{C}$, is determined by:

$$\overline{C}=\frac{\Sigma D}{\Sigma P}\times 1000$$

The April 1964 average concentrations and total depositions are given in table 2.

2. Canadian Air Monitoring Program,[4] April 1964

Department of National Health and Welfare, Ottawa, Canada

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas-flow, Geiger-Mueller counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for April 1964 are given in table 3 and presented in conjunction with U. S. and Mexican data by an isogram map (figure 5).

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

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[4] Data from *Radiation Protection Programs 4:* 11–24, Radiation Protection Division, Canadian Department of National Health and Welfare (May 1964).

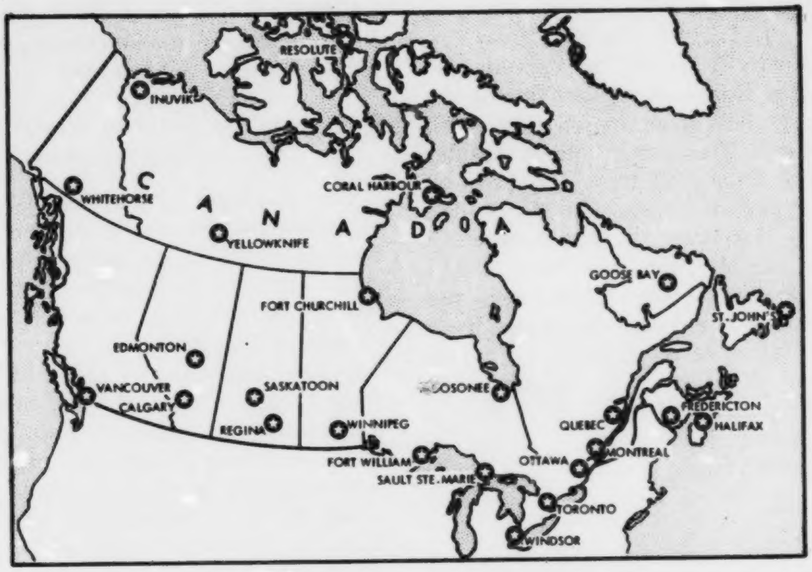
RESOLUTE
INUVIK
C A N A D A
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
SASKATOON
VANCOUVER
CALGARY
REGINA
WINNIPEG
MOOSONEE
FREDERICTON
QUEBEC
HALIFAX
MONTREAL
OTTAWA
FORT WILLIAM
SAULT STE. MARIE
TORONTO
WINDSOR

FIGURE 3.—CANADIAN AIR AND PRECIPITATION STATIONS, APRIL 1964

TABLE 3.—GROSS BETA ACTIVITY IN AIR, CANADA, APRIL 1964

[Concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Calgary	28	3.7	0.5	1.7
Coral Harbour	30	1.9	0.5	1.2
Edmonton	30	3.1	0.5	1.3
Ft. Churchill	30	2.6	0.5	1.3
Ft. William	29	3.5	0.1	1.5
Fredericton	29	2.6	0.1	1.4
Goose Bay	30	2.6	0.5	1.5
Halifax	29	3.6	0.1	1.6
Inuvik	29	2.3	0.9	1.5
Montreal	30	3.5	0.1	1.6
Moosonee	29	2.9	0.3	1.7
Ottawa	30	2.9	0.1	1.4
Quebec	30	2.9	0.1	1.5
Regina	30	3.7	0.7	1.8
Resolute	30	2.8	0.6	1.4
St. John's, Nfld	30	2.6	0.1	1.1
Saskatoon	30	3.3	0.9	1.7
Sault Ste. Marie	30	2.7	0.2	1.4
Toronto	30	3.0	0.2	0.7
Vancouver	30	1.9	0.2	0.9
Whitehorse	30	2.6	0.2	0.9
Windsor	28	3.9	0.5	1.8
Winnipeg	30	3.1	0.5	2.0
Yellowknife	30	2.4	0.6	1.5
Network summary	711	3.9	0.1	1.4

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450°C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}–Y^{90} source. Gross beta activities for April 1964 samples are given in table 4. Radionuclide analyses appear quarterly.

TABLE 4.—GROSS BETA ACTIVITY IN PRECIPITATION, CANADA, APRIL 1964

Station	Total beta activity	
	pc/liter	nc/m²
Calgary	1,080	14.2
Coral Harbour	678	4.5
Edmonton	1,500	28.6
Ft. Churchill	905	11.0
Ft. William	749	102.4
Fredericton	531	53.6
Goose Bay	1,256	30.6
Halifax	641	74.5
Inuvik	491	4.0
Montreal	696	43.1
Moosonee	1,059	41.6
Ottawa	746	48.8
Quebec	778	42.6
Regina	2,695	15.7
Resolute	128	10.7
St. John's, Nfld	373	36.6
Saskatoon	—[a]	—
Sault Ste. Marie	1,080	59.2
Toronto		
Vancouver	1,104	39.3
Whitehorse	393	5.0
Windsor	862	92.9
Winnipeg	734	39.8
Yellowknife	855	6.5
Average	879	36.6

[a] Dash indicates no sample collected.

3. Mexican Air Monitoring Program
April 1964

National Commission of Nuclear Energy

As part of its Radiological Protection Program (RPP), the Comisión Nacional de Energía Nuclear (CNEN) established the Radiation Surveillance Network of Mexico to provide a means for determining increased levels of radioactivity in air and precipitation.

The network has been gradually expanded to 17 stations (see figure 4). Twelve of the 17 stations are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí and Ensenada; Staff Members of the RPP operate the station at Mexico City while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Instituto de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week, at the rate of approximately 1,200 cubic meters per day, through a high-efficiency glass fiber filter, 6" x 8", using high volume samplers. After each 24-hour period, the filter is removed and forwarded via air mail to the 'Laboratorio de Estudios Sobre Contaminación Radiactiva," CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughters' natural radioactivity. Data are not extrapolated to time of collection.

The maximum, minimum and average fission product beta concentrations in surface air during April 1964 are presented in table 5.

TABLE 5.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, APRIL 1964

[Concentrations in pc/m³]

Station	Number of Samples	Maximum	Minimum	Average
Acapulco [a]	—	—	—	—
Ciudad Juárez	22	4.0	0.6	2.1
Chihuahua	19	6.3	1.1	3.0
Ensenada	13	3.6	0.6	1.8
Guadalajara	15	1.0	0.2	0.6
Guaymas	18	2.1	0.1	1.0
La Paz	17	4.4	1.0	2.2
Matamoros [a]	—	—	—	—
Mazatlán	17	3.8	1.2	2.4
Mérida	20	2.1	0.2	0.8
México, D.F.	19	0.8	0.1	0.3
Nuevo Laredo	4	2.3	0.4	—
San Luis Potosí	13	1.0	0.3	0.6
Tampico	9	1.0	0.5	0.7
Torreón	16	5.1	0.5	1.7
Tuxtla Gutiérrez [a]	—	—	—	—
Veracruz	13	1.4	0.3	0.7
Network summary	215	6.3	0.1	1.4

[a] Temporarily shut down.

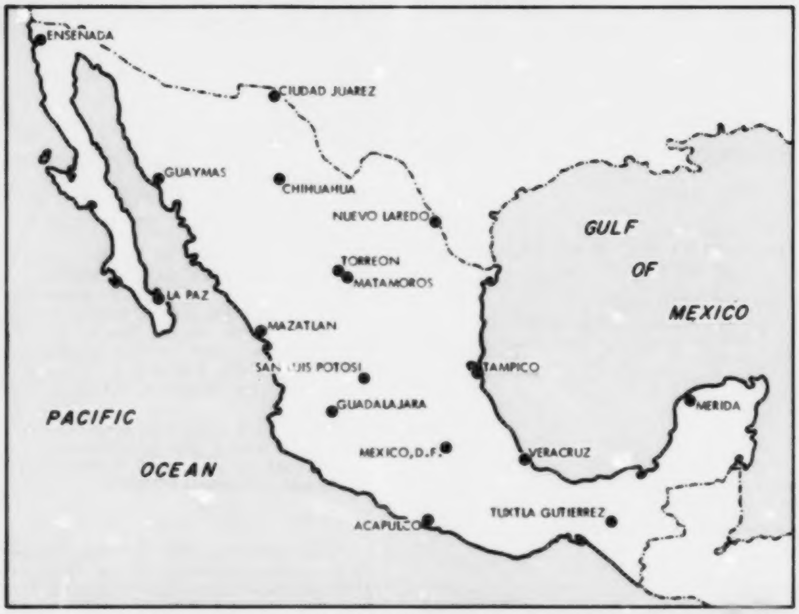

FIGURE 4.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

59

4. Pan American Air Sampling Program April 1964

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by three countries in South America under the auspices of a collaborative program developed by the Pan American Health Organization and the Public Health Service (PHS) for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The four air sampling stations included in the program are operated by technical staff of the Ministry of Health in each country. The station in Kingston, Jamaica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupational Health; and in Santiago, Chile, by the Occupational Health Service. The Kingston station began operation in March 1964; the others were started in the latter part of 1962.

The April 1964 air monitoring results from the four participating countries are given in table 6. The Caracas and Jamaica stations, included in figure 5 with the April averages adjusted by the RSN intercalibration factor,[5] were used in positioning the beta concentration isograms.

TABLE 6.—GROSS BETA ACTIVITY IN AIR, APRIL 1964

[Concentrations in pc/m³]

Sampling stations	No. of samples	Maximum	Minimum	Average [a]
Kingston, Jamaica	25	1.35	0.30	0.74
Caracas, Venezuela	21	1.80	0.27	0.68
Lima, Peru	8	0.12	<0.10	<0.10
Santiago, Chile	18	0.18	<0.10	<0.11

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

5. Gross Beta Activity in Air, North America April 1964

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America.[6] The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*8*).

With the formation of the Mexican Air monitoring program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, National Air Sampling Network, the HASL 80th Meridian Network, and the Mexican Network (*9*). The new intercalibration factors reflect some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963.

Figure 5 shows the April 1964 activity in air throughout North America based on the data from the Canadian Air Monitoring Program, the Radiation Surveillance Network and Mexican Air Monitoring program. An intercalibration factor of 1.28 was applied to the RSN data and the Mexican data were multiplied by 0.81 in order to adjust them to Canadian data.

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(*1*) Radiation Surveillance Network: *Monthly Tabulation of Findings*, Division of Radiological Health, Public Health Service, Washington, D. C. 20201 (Distribution by official request).

(*2*) Way, K., E. P. Wigner: The Rate of Decay of Fission Products, *Physical Review, 73:* 1318–30 (June 1, 1948).

(*3*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1959 on the Radioactive Fallout Study Program, CNHW–RP–3*, Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*4*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4*, Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*5*) Mar, P. G.: *Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5*, Department of National Health and Welfare, Ottawa, Canada (December 1962).

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[5] The RSN factor is 1.28.

[6] The January 1963 through February 1964 isogram maps were published in the May 1963 through June 1964 issues of *Radiological Health Data*.

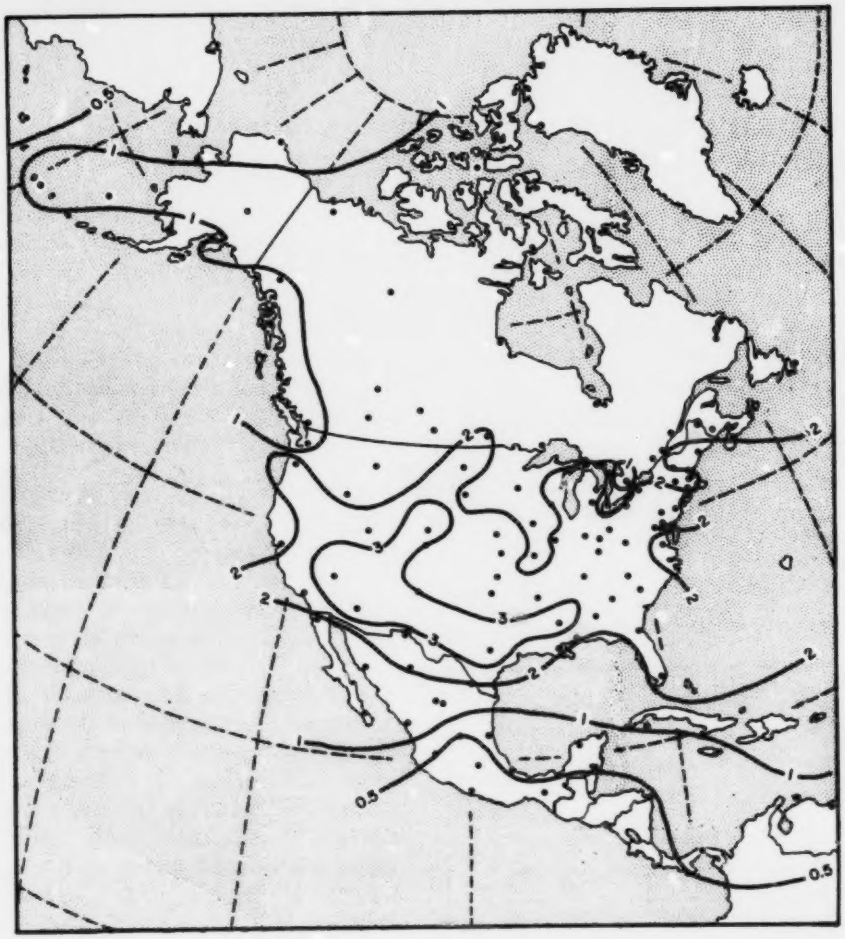

FIGURE 5.—ISOGRAMS OF AVERAGE GROSS BETA CONCENTRATIONS IN AIR THROUGHOUT NORTH AMERICA (pc/m^3), APRIL 1964

(6) Beale, J. and J. Gordon: *The Operation of the Radiation Protection Division Air Monitoring Program RPD–11*, Department of National Health and Welfare, Ottawa, Canada (July 1962).

(7) Booth, A. H.: *The Calculation of Maximum Permissible Levels of Fallout in Air and Water and Their Use in Assessing the Significance of 1961 Levels in Canada, RPD–21*, Department of National Health and Welfare, Ottawa, Canada (August 1962).

(8) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850*, Naval Research Laboratory, Washington, D. C. 20390 (November 13, 1962); abstracted in *Radiological Health Data*, December 1962.

(9) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: *Intercalibration of the Major North American Networks Employed in Monitoring Airborne Fission Products, NRL Report 6025*, Naval Research Laboratory, Washington, D. C. 20390 (December 1963); summarized in *Radiological Health Data*, January 1964.

FISSION PRODUCT GAMMA ACTIVITY IN SURFACE AIR—80TH MERIDIAN AND U.S. LOCATIONS

William R. Collins, Jr.[1]

80th Meridian Network, March and April 1964

Fourteen air sampling stations near the 80th Meridian (West) from Thule, Greenland, to Punta Arenas, Chile, make up the Health and Safety Laboratory (HASL) 80th Meridian Network (figure 1). An additional station at Mauna Loa, Hawaii, is included for comparing data with that from Chacaltaya, Bolivia; both are at a high elevation and their respective latitudes north and south are nearly equal.

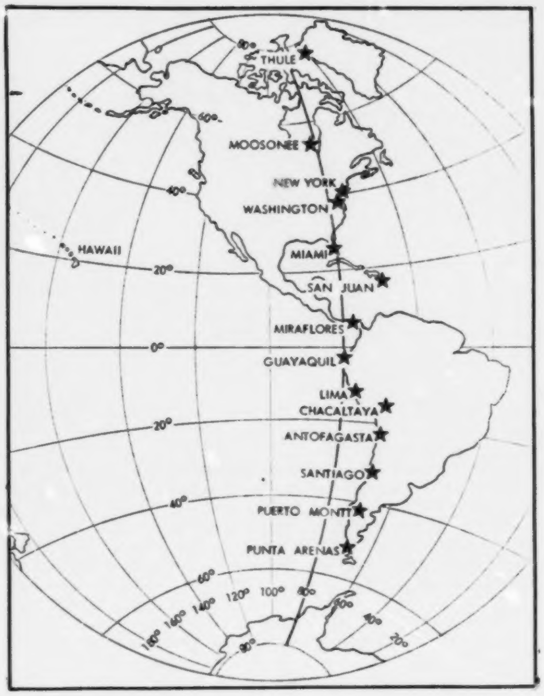

FIGURE 1.—80TH MERIDIAN NETWORK SAMPLING STATIONS (6 NEW U. S. STATIONS NOT SHOWN)

Air particulates are sampled on 8-inch-diameter polystyrene (Microsorban) filters, drawing air through the filters continuously at the rate of about 1400 cubic meters per day. Filters are changed on the 1st, 8th, 15th and 22nd of each month and forwarded to HASL for analysis. A total gamma count over the energy range, 0–3 Mev, is made approximately two weeks after the end of the sampling period, using an 8 x 4-inch sodium iodide (thallium-activated) crystal. The filters are then composited on a monthly basis and analyzed radiochemically, together with monthly ground deposition samples taken at the same site, for detectable fission and neutron activation products.

The results of total gamma activity determinations in weekly ground level air filter samples taken at 80th Meridian stations during March and April 1964 are listed in tables 1 and 2, together with average monthly activity concentrations calculated for each site. The average monthly activities are also plotted in figure 2 as activity-latitude profiles.

The monthly averages for all of the northern sites were 0.77, 0.85, 0.99 and 0.97 $\gamma/\text{min}/\text{m}^3$, respectively, for January through April. The corresponding averages in the Southern Hemisphere were 0.055, 0.051, 0.063, and 0.048 $\gamma/\text{min}/\text{m}^3$. The data appear to follow the pattern of the usual spring rise in the Northern Hemisphere.

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[1] Mr. Collins is a chemist on the staff of the Environmental Studies Division, Health and Safety Laboratory, U. S. Atomic Energy Commission.

62

Table 1.—GAMMA ACTIVITY IN SURFACE AIR, 80TH MERIDIAN NETWORK, MARCH 1964

[Activity in gamma photons/min/m³]

Station latitude, elevation	March sampling periods				Marc average
	1-7	8-14	15-21	22-31	
Thule, Greenland 77° N, 259 m	0.693	0.983	0.947	1.08	0.940
Moosonee, Canada 51° N, 10 m	0.850	0.765	0.961	1.01	0.911
New York, N. Y. 41° N, 38 m	0.793	1.39	0.990	1.11	1.03
Washington, D. C. 39° N, 82 m	0.974	1.23	1.14	1.30	1.17
Miami, Fla. 26° N, 4 m	1.91	1.24	1.30	1.75	1.60
Mauna Loa, Hawaii 19° N, 3394 m	0.592	0.506	0.881	0.768	0.701
San Juan, P. R. 18° N, 10 m	1.87	0.314	0.722	0.221	0.724
Miraflores, Canal Zone 9° N, 10 m	0.755	0.852	0.268	1.38	0.859
Guayaquil, Ecuador 0°-08′ S, 7 m	0.131	0.357	0.148	0.106	0.185
Lima, Peru 12° S, 50 m	0.0796	0.113	0.0624	0.0577	0.0768
Chacaltaya, Bolivia 17° S, 5220 m	0.0200	0.0260	0.00946	0.0219	0.0196
Antofagasta, Chile 24° S, 519 m	0.0397	0.0791	0.0572	0.0435	0.0539
Santiago, Chile 33° S, 5 m	0.0406	0.0644	0.0357	0.0569	0.0499
Puerto Montt, Chile 41° S, 5 m	0.0424	0.0270	0.0369	0.0330	0.0346
Punta Arenas, Chile 53° S, 3 m	0.0163	0.0181	0.0192	0.0103	0.0155

Table 2.—GAMMA ACTIVITY IN SURFACE AIR, 80TH MERIDIAN NETWORK, APRIL 1964

[Activity in gamma photons/min/m³]

Station latitude, elevation	April sampling periods				April average
	1-7	8-14	15-21	22-31	
Thule, Greenland 77° N, 259 m	1.09	1.18	1.13	0.894	1.06
Moosonee, Canada 51° N, 10 m	1.05	1.08	1.10	1.06	1.07
New York, N. Y. 41° N, 38 m	0.957	1.55	0.432	1.03	1.00
Washington, D. C. 39° N, 82 m	0.981	1.55	1.10	0.412	0.972
Miami, Fla. 26° N, 4 m	1.57	0.750	2.02	0.846	1.26
Mauna Loa, Hawaii 19° N, 3394 m	0.857	1.28	0.546	0.866	0.887
San Juan, P. R. 18° N, 10 m	0.655	0.834	0.942	0.747	0.791
Miraflores, Canal Zone 9° N, 10 m	1.16	0.655	0.714	0.148	0.633
Guayaquil, Ecuador 0°-08′ S, 7 m	0.139	0.0769	0.0856	0.0510	0.0832
Lima, Peru 12° S, 30 m	0.0972	0.0117	0.0610	0.0500	0.0549
Chacaltaya, Bolivia 17° S, 5220 m	0.0376	0.0318	0.0225	0.0227	0.0281
Antofagasta, Chile 24° S, 519 m	0.0589	0.0506	0.0501	0.0588	0.0549
Santiago, Chile 33° S, 5 m	0.0885	0.0749	0.0393	0.0321	0.0577
Puerto Montt, Chile 41° S, 5 m	0.0454	0.0457	0.0228	0.0313	0.0359
Punta Arenas, Chile 53° S, 3 m	0.0198	0.0218	0.0197	0.0103	0.0174

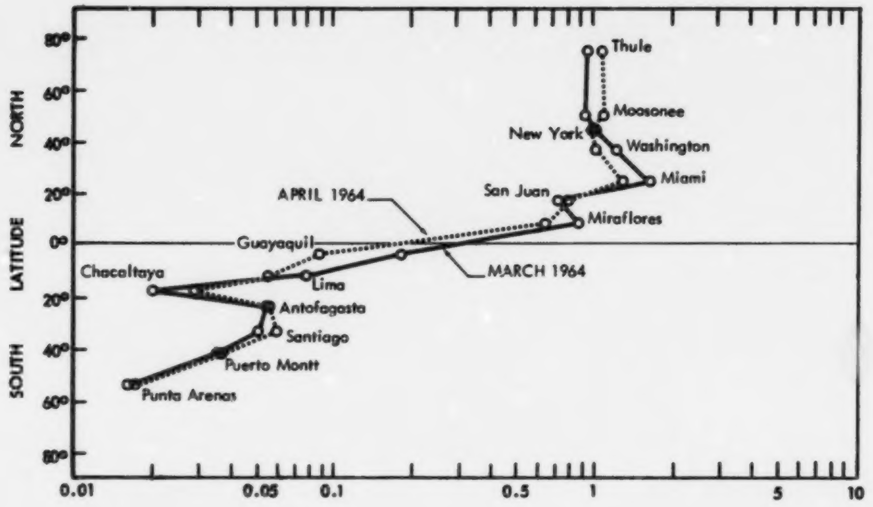

Figure 2.—PROFILE OF SURFACE AIR GAMMA ACTIVITY, MARCH AND APRIL 1964

Additional United States Sites

Since August 1963 the following sites have been added to the HASL ground level air sampling network:

	Longitude	*Latitude*	*Elevation*
Westwood, N.J.	74°01′W	41°00′N	38 m
Chattanooga, Tenn.	85°20′W	35°03′N	206 m
Appleton, Wis.	88°25′W	44°15′N	229 m
Midwest City, Okla.	97°30′W	35°25′N	364 m
Seattle, Wash.	122°20′W	47°36′N	3 m
Palo Alto, Calif.	122°23′W	37°30′N	19 m

As with the original 80th Meridian sites, both air filter and deposition samples are taken at the new stations using the equipment and methods described above.

The actual maintenance of the new sites and individual radionuclide determinations are performed by Food, Chemical and Research Laboratories, Inc. of Seattle for the Seattle site, by Hazelton-Nuclear Science Corporation of Palo Alto for the Palo Alto and Midwest City sites and by Isotopes, Inc. of Westwood for the Westwood, Chattanooga and Appleton sites. Deposition data from these sources are reported in the HASL Fallout Program Quarterly Summary Reports. The surface air data will be reported as it becomes available in the monthly 80th Meridian reports.

Average monthly total gamma activity concentrations calculated from data received for weekly samples taken at the new sites from August 1963 through April 1964 are given in table 3. These data are in fair agreement with total gamma activity measurements previously reported for 80th Meridian sites at similar latitudes, indicating that latitude had no great effect on ground level air activity concentrations in the United States during the period of observation covered by the data. The data in table 3 also reflect the usual spring increases in the Northern Hemisphere with concentrations averaging 0.91, 0.87, 1.05, and 1.22 γ photons/min/m^3 for the January through April 1964 period.

TABLE 3.—GAMMA ACTIVITY IN SURFACE AIR, UNITED STATES SITES

[Activity in γ photons/min/m^3]

Station	August 1963	September 1963	October 1963	November 1963	December 1963	January 1964	February 1964	March 1964	April 1964
Westwood	4.53	1.96	1.58	0.782	0.625	0.645	0.934	0.964	1.07
Chattanooga	5.25	2.14	1.93	0.840	0.676	0.844	0.666	1.02	1.45
Appleton	5.07	1.67	1.54	0.690	0.527	0.580	0.690	1.03	0.947
Midwest City	5.64	2.17	2.82	2.53	1.78	1.51	1.22	1.73	1.95
Seattle	1.74	1.25	1.31	0.757	1.09	0.620	0.612	0.492	0.662
Palo Alto	4.33	2.27	2.84	1.42	1.28	1.28	1.10	1.04	1.24

MONTHLY DEPOSITION OF VARIOUS RADIONUCLIDES

For the purpose of this section the word "fallout" refers to the deposition of radioactive materials on the earth's surface, normally expressed in terms of the activity of selected radionuclides deposited on a unit area during a given period of time. Unless otherwise stated, fallout measurements include both precipitation and dry fallout (settled dust).

Reports of fallout measurements at selected stations in North and South America are presented below.

1. Fallout in the United States and Other Areas[1] July–December 1963

Health and Safety Laboratory
Atomic Energy Commission

Monthly fallout deposition rates are determined by the Health and Safety Laboratory (HASL) for 48 sites in the United States and 104 locations in other countries. HASL data from 10 of the U. S. stations and 21 other selected points in the Western Hemisphere (see figure 1) covering the period from July through December 1963 are summarized below. All of the stations of the 80th Meridian Network are represented.

Methods of Collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of one month in stainless steel pots with exposed areas of 0.076m^2. At the end of the collection period, the contents are transferred, by careful scrubbing with a rubber spatula, to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

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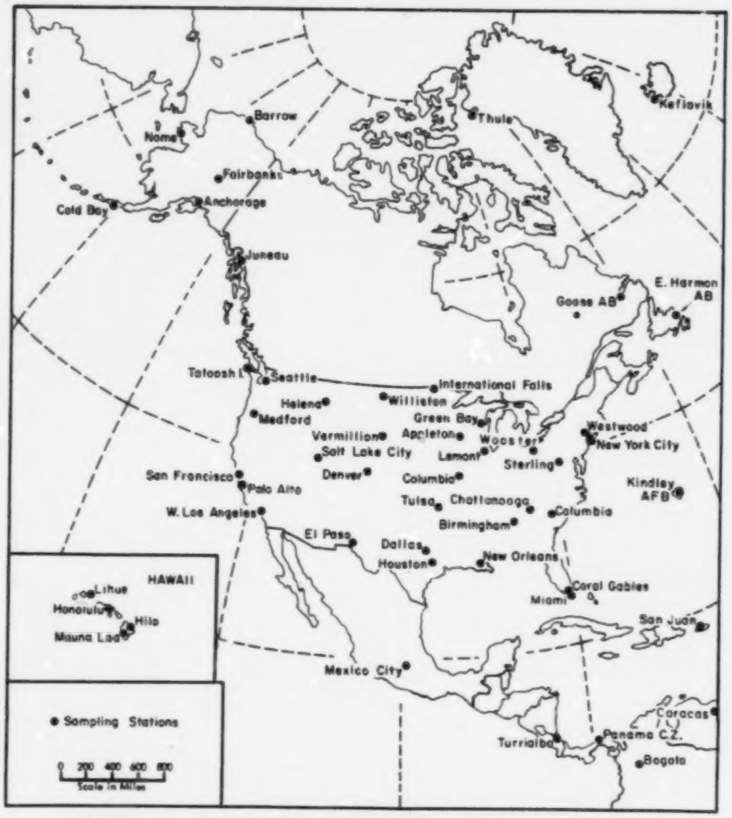
[1] The data in this article were taken from *Fallout Program Quarterly Summary Report, HASL-144:* 2–172, Health and Safety Laboratory, AEC, New York, N.Y. 10014.



Barrow
Nome
Fairbanks
Cold Bay
Anchorage
Juneau
Thule
Keflavik
Goose AB
E. Harmon AB
Tatoosh I.
Seattle
International Falls
Helena
Williston
Medford
Green Bay
Vermillion
Appleton
Salt Lake City
Lemont
Wooster
Westwood
New York City
Sterling
San Francisco
Denver
Columbia
Palo Alto
Kindley AFB
Tulsa
Chattanooga
W. Los Angeles
Columbia
Birmingham
El Paso
Dallas
Houston
New Orleans
Coral Gables
Miami
HAWAII
Lihue
Honolulu
Hilo
Mauna Loa
San Juan
Mexico City
Sampling Stations
0 200 400 600 800
Scale in Miles
Caracas
Turrialba
Panama C.Z.
Bogota

FIGURE 1.—HASL FALLOUT SAMPLING LOCATIONS

The second method involves the use of a polyethylene funnel, with an exposed area of $0.072 m^2$ attached to an ion exchange column. After a one-month collection, the inside of the funnel is wiped with a tissue, and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95 percent confidence level there was no significant difference in the strontium-90 measurements obtained from samples collected by the two methods (*1*).

Strontium-90

All of the HASL fallout samples—both pot and column—were assayed for strontium-90 and strontium-89. The strontium-90 data are given in tables 1 and 2 for 58 selected stations. Where duplicate samples were collected, the average values are given.

Other Radionuclides

Laboratories at Westwood, New Jersey; Chattanooga, Tennessee; Seattle, Washington; and Appleton, Wisconsin have analyzed duplicate monthly pot samples for various radionuclides. The monthly deposition rates for Sr^{89}, Sr^{90}, Ce^{144}, Cs^{137}, Zr^{95}, Mn^{54} and precipitation depth are presented in table 3.

TABLE 1.—MONTHLY STRONTIUM-90 FALLOUT IN THE UNITED STATES, HASL, JULY-DECEMBER 1963

[Deposition in nc/m²]

Sampling location and type of collection			July	August	September	October	November	December
Ala:	Birmingham	(pot)	4.94	0.88	0.51	0.13	0.05	0.77
Alaska:	Anchorage	(col)	[a]	4.00	0.63	0.32	0.12	0.19
	Barrow	(col)	[a]	[a]	0.07	0.36	0.09	0.09
	Cold Bay	(col)	2.81	2.31	1.46	0.37	0.31	0.25
	Fairbanks	(col)	2.54	1.62	0.19	0.17	0.02	0.07
	Juneau	(col)	5.07	1.40	[a]	0.37	0.41	0.91
	Nome	(col)	[a]	[a]	[a]	[a]	[a]	0.20
Calif:	W. Los Angeles	(pot)	0.046	0.11	0.45	0.27	0.42	0.03
	Palo Alto	(col)	0.0386	0.08	0.12	0.20	0.47	0.07
	Palo Alto	(pot)	[a]	[a]	[a]	[a]	0.34	0.03
	San Francisco	(col)	0.0015	0.027	0.07	0.29	0.41	0.36
Colo:	Denver	(col)	1.12	1.66	0.19	0.82	0.67	0.10
Fla:	Coral Gables	(pot)	0.64	0.59	1.47	[a]	0.35	0.43
	Miami	(col)	0.90	0.76	0.61	1.24	0.32	0.31
Hawaii:	Hilo	(col)	2.86	2.76	1.50	1.80	1.06	0.24
	Lihue	(col)	0.56	0.230	0.22	0.22	0.10	0.35
	Mauna Loa	(col)	0.39	0.18	0.16	0.03	0.02	0.23
	Oahu	(pot)	1.31	0.88	0.90	0.44	0.17	0.78
Ill:	Argonne	(pot)	3.31	0.42	0.37	0.51	0.25	0.18
La:	New Orleans	(col)	1.92	1.0	0.29	0.10	0.71	0.58
Minn:	International Falls	(col)	5.09	2.80	0.89	0.25	0.37	0.20
Mo:	Columbia	(col)	2.6	2.0	0.69	0.51	0.33	0.14
Mont:	Helena	(col)	0.18	1.21	0.67	0.72	0.12	0.16
N. J:	Westwood	(col)	5.20	2.21	2.1	0.60	0.98	0.55
	Westwood	(pot)	4.6	2.03	1.80	0.58	0.96	0.54
N. Y:	New York	(pot)	2.64	1.85	1.12	0.12	1.79	0.83
N. Dak:	Williston	(col)	1.32	0.44	0.25	0.07	0.19	0.25
Okla:	Tulsa	(pot)	2.72	1.05	[a]	0.60	[a]	0.17
Ore:	Medford	(col)	0.71	0.54	0.26	0.031	0.42	0.33
Ohio:	Wooster	(pot)	[a]	1.31	0.54	0.21	0.40	0.12
S. C:	Columbia	(col)	2.0	0.58	0.48	0.03	0.56	0.68
S. Dak:	Vermillion	(pot)	2.1	1.57	0.49	0.45	0.09	0.01
Tex:	Dallas	(col)	0.52	0.10	0.12	0.15	0.55	0.15
	El Paso	(col)	0.60	0.55	0.11	0.13	0.37	0.05
	Houston	(col)	0.72	0.30	0.20	0.14	0.60	0.96
Utah:	Salt Lake City	(pot)	0.18	0.73	0.93	0.88	0.56	0.29
Va:	Sterling	(col)	1.03	1.42	0.43	0.12	0.86	0.21
Wash:	Seattle	(pot)	1.47	0.66	0.81	1.4	1.64	1.19
	Tatoosh Island	(col)	3.2	[a]	1.7	2.9	2.22	0.12
Wis:	Green Bay	(col)	2.2	1.2	1.07	0.50	0.42	0.17

[a] Not received

TABLE 2.—MONTHLY STRONTIUM-90 FALLOUT IN NORTH AND SOUTH AMERICA—HASL, JULY-DECEMBER 1963

[Deposition in nc/m²]

Station [a]	Collection period					
	July	August	September	October	November	December
Bermuda	0.97	1.1	0.49	0.80	0.43	1.40
Bolivia:						
La Paz	0.03	0.008	0.07	0.12	0.05	0.05
Chacaltaya [b]	0.12	0.05	0.08	0.05	0.60	0.07
Brazil:						
Belem	0.05	0.08	0.08	0.09	0.01	0.09
Nova Friburgo	0.02	0.05	0.02	1.04	0.06	[c]
Rio de Janeiro	0.05	0.09	0.03	0.28	0.14	0.03
Canada:						
Ontario, Moosonee [b]	2.2	1.80	0.70	0.52	0.14	0.07
Ernest Harman AB	2.5	2.3	1.3	0.79	0.08	0.11
Goose AB	3.7	1.32	1.13	0.37	0.29	0.21
Chile:						
Antofagasta [b]	0.004	[c]	0.007	0.17	0.02	0.02
Puerto Montt [b]	0.22	0.02	0.01	0.05	[c]	0.18
Punta Arenas [b]	[c]	0.06	0.05	[c]	0.04	0.15
Santiago [b]	0.17	0.47	0.031	0.04	0.04	0.04
Colombia, Bogota	0.04	0.03	0.02	0.03	0.05	0.02
Costa Rica, Turrialba	0.35	0.17	0.14	0.29	0.13	0.26
Ecuador:						
Guayaquil [b]	0.02	0.007	0.007	0.05	0.02	0.22
Quito	0.03	0.01	0.015	0.03	[c]	0.03
Greenland, Thule	0.83	2.0	0.15	0.88	0.04	0.04
Iceland, Keflavik	0.98	0.46	1.12	1.2	0.29	Lost
Mexico, Mexico City	1.00	1.0	0.30	0.2	0.04	1.79
Canal Zone	0.37	0.32	0.11	0.11	0.57	0.10
Peru, Lima [b]	0.02	[b]	0.03	0.03	0.06	0.04
Puerto Rico, San Juan	0.84	0.84	0.72	0.12	0.39	0.20
Venezuela, Caracas	0.65	0.34	0.22	0.25	0.22	0.09

[a] All samples are from columns except at Nova Friburgo, where pot collection is done.
[b] 80th Meridian Network station.
[c] No sample received.

2. Fallout Measurements in Canada January–March 1964

Department of National Health and Welfare
Ottawa, Canada

The monthly accumulated precipitation samples collected in conjunction with the Canadian air sampling network described earlier in this issue represent total fallout (wet and dry), since they are collected in deep pots lined with polyethylene. The radiochemical analyses of these samples for January through March 1964 are given in table 4.

REFERENCE

(1) Ong, L. D. Y., Homogeneity Between Pot and Ion Exchange Column Strontium-90 Measurements, *Fallout Program Quarterly Summary Report, HASL-135:* 256–69, Office of Technical Services, Department of Commerce, Washington 25, D. C. (April 1, 1963), price $4.00.

67

TABLE 3.—RADIOCHEMICAL ANALYSES OF POT FALLOUT SAMPLES—HASL, JULY-DECEMBER 1963

[Deposition in nc/m²]

Location and analyses	July	August	September	October	November	December
California, Palo Alto						
Precipitation (mm)	Dry	Trace	4.57	25.15	69.59	Trace
Sr^{89}	0.70	0.92	0.15	0.14	0.30	0.02
Sr^{90}	0.15	0.33	0.11	0.14	0.34	0.03
Ce^{144}	0.32	1.64	2.71	2.29	4.71	2.03
Cs^{137}	0.05	0.20	0.25	0.34	0.74	0.22
Zr^{95}	0.11	0.50	0.68	0.61	1.03	0.27
Mn^{54}	<0.02	0.33	0.36	0.59	0.67	0.28
New Jersey, Westwood						
Precipitation (mm)	120.9	45.7	119	23.4	113.8	38.35
Sr^{89}	12.4	4.01	2.6	0.60	0.59	0.19
Sr^{90}	5.2	2.20	2.06	0.60	0.98	0.55
Ce^{144}	71.8	47.9	36.4	11.3	20.8	11.58
Cs^{137}	6.7	4.7	3.40	0.99	1.87	0.63
Zr^{95}	33.2	Lost	8.06	2.04	Lost	1.74
Mn^{54}	9.3	6.3	4.5	1.15	Lost	1.32
Oklahoma, Midwest City						
Precipitation (mm)	150.87	62.23	45.97	5.08	50.5	17.02
Sr^{89}	7.68	1.67	0.60	0.18	1.21	0.07
Sr^{90}	1.67	0.55	0.37	0.15	1.21	0.08
Ce^{144}	23.35	15.86	8.95	2.62	5.02	2.60
Cs^{137}	2.84	1.72	0.76	0.35	0.97	0.30
Zr^{95}	6.83	3.31	1.97	1.13	1.06	0.04
Mn^{54}	2.86	1.73	1.72	0.39	0.97	0.24
Tennessee, Chattanooga						
Precipitation (mm)	[a]—	21	23.8	Dry	173.2	119.40
Sr^{89}	—	1.00	0.37	<0.05	0.45	0.38
Sr^{90}	—	0.58	0.37	0.05	0.78	0.61
Ce^{144}	—	11.4	7.1	1.9	15.0	15.20
Cs^{137}	—	1.0	0.64	0.12	1.61	1.16
Zr^{95}	—	4.60	2.7	4.60	1.32	1.67
Mn^{54}	—	0.63	0.78	<0.28	0.51	0.68
Washington, Seattle						
Precipitation (mm)	50	39.8	23.8	106.4	201.2	120.70
Sr^{89}	1.4	1.5	0.21	1.0	0.2	0.4
Sr^{90}	0.49	0.69	0.93	1.0	1.5	1.1
Ce^{144}	5.4	11.8	12.5	14	16.3	17.1
Cs^{137}	0.52	0.89	1.2	0.81	1.6	1.8
Zr^{95}	2.4	4.8	3.6	3.0	2.2	1.63
Mn^{54}	1.4	2.8	1.4	2.3	2.0	1.16
Wisconsin, Appleton						
Precipitation (mm)	—	50.3	97	15.7	42.9	14.48
Sr^{89}	—	2.8	2.1	0.67	0.54	0.10
Sr^{90}	—	1.5	1.53	0.67	0.94	0.20
Ce^{144}	—	28.8	27.2	12.8	17.2	4.98
Cs^{137}	—	2.2	2.5	1.4	1.70	0.17
Zr^{95}	—	Lost	7.5	2.2	2.2	0.51
Mn^{54}	—	1.9	2.9	1.5	—	0.48

[a] Dash indicates no sample received.

TABLE 4.—ANALYSIS FOR SPECIFIC RADIONUCLIDES IN CANADIAN FALLOUT, JANUARY-MARCH 1964

[Deposition in nc/m²]

Station	January					February					March [a]	
	Sr^{89}	Sr^{90}	Cs^{137}	Zr^{95}	Ba^{140}	Sr^{89}	Sr^{90}	Cs^{137}	Zr^{95}	Ba^{140}	Sr^{90}	Cs^{137}
Calgary	0.00	0.05	0.17	0.10	0.06	0.00	0.17	0.27	0.06	0.12	0.12	0.34
Coral Harbour	0.00	0.15	0.27	[b]—	—	0.00	0.88	1.09	—	—	0.04	0.08
Edmonton	0.00	0.14	0.30	—	—	0.00	0.16	0.38	—	—	0.15	0.47
Ft. Churchill	0.00	0.14	0.15	—	—	0.00	0.07	0.14	—	—	0.08	0.14
Ft. William	0.14	0.49	1.19	—	—	0.00	0.09	0.17	—	—	0.27	0.48
Fredericton	0.20	0.62	0.89	—	—	0.08	0.41	0.74	—	—	1.52	2.51
Goose Bay	0.00	0.25	0.54	—	—	0.11	0.27	0.27	—	—	0.69	1.04
Halifax	0.38	1.12	1.72	0.58	0.03	0.21	[illegible]	2.14	0.86	0.19	1.18	1.54
Inuvik	0.00	0.17	0.17	—	—	0.06	0.19	0.36	—	—	0.04	0.10
Montreal	0.19	1.25	1.95	1.01	0.09	0.00	0.43	0.74	0.33	0.09	[illegible]	1.35
Moosonee	0.17	0.44	0.80	—	—	0.05	0.26	0.37	—	—	0.32	0.62
Ottawa	0.16	0.45	0.85	—	—	0.00	0.19	0.28	—	—	0.49	0.96
Quebec	0.41	1.01	2.09	—	—	0.18	0.61	1.20	—	—	0.48	2.02
Regina	0.00	0.11	0.10	—	—	0.00	0.11	0.30	—	—	0.16	0.27
Resolute	0.25	0.86	1.20	—	—	0.09	0.59	0.79	—	—	0.26	0.40
St. John's, Nfld.	—	—	—	—	—	0.05	1.57	2.00	—	—	1.31	2.24
Saskatoon	0.00	0.12	0.18	—	—	0.00	0.14	0.25	—	—	0.09	0.13
Saulte Ste. Marie	0.00	0.76	1.30	—	—	0.07	0.29	0.55	—	—	1.06	1.81
Toronto	0.00	0.26	0.90	—	—	0.09	0.20	0.54	—	—	1.30	2.00
Vancouver	0.67	1.84	3.32	1.88	0.03	0.18	0.93	1.75	0.36	0.08	1.89	2.80
Whitehorse	0.00	0.00	0.13	—	—	0.00	0.09	0.18	—	—	0.04	0.24
Windsor	0.28	0.65	1.24	—	—	0.06	0.39	0.66	—	—	1.73	0.52
Winnipeg	0.00	0.12	0.17	0.13	0.04	0.00	0.08	0.17	0.10	0.11	0.20	0.36
Yellowknife	0.00	0.11	0.16	—	—	0.00	0.12	0.16	—	—	0.17	0.22

[a] Sr^{89}, Zr^{95} and Ba^{140} were not recorded for March because of insignificantly low levels.

[b] Dash indicates no analysis.

Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, April 1964

Division of Radiological Health and
Division of Environmental Engineering and
Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. Composites of the samples are preserved with formaldehyde and are sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL) for analysis. Gamma analyses for iodine-131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after collection; publication in *RHD* follows 3 to 4 months after sample collection.

Sampling and Compositing Procedures

The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

69

Analytical Errors

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectroscopy.[1] After the weekly samples are gamma scanned, samples from two consecutive weeks are composited and analyzed radiochemically for strontium–89 and strontium–90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation is dependent upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclide and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. The ±2 standard deviations (2σ) about the measured concentration correspond to a 95 percent certainty that the true concentration is within this range. The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error [a] (pc/liter)	Estimated concentration (pc/liter)	Error [a] (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10%
Barium-140	0 to 100	±10	100 or greater	±10%
Cesium-137	0 to 100	±10	100 or greater	±10%
Strontium-89	0 to 50	±5	50 or greater	±10%
Strontium-90	0 to 20	±2	20 or greater	±10%

[a] Two standard deviations (2σ).

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium–40 concentrations[2] determined from the gamma spectrum.

Data Presentation

Table 2 presents summaries of the analyses for April 1964 (March 29–April 25, 1964). Although not shown in table 2, the iodine–131 and barium–140 monthly average concentrations in milk were less than 10 pc/liter. Radionuclide values reported by a laboratory as being below the minimum detectable concentration have been averaged by using one-half the minimum detectable value. The averaging procedure was modified for iodine–131 and barium–140 in October 1963, when nondetectable concentrations of these radionuclides were considered to be zero.

Figures 1 and 2 are isogram maps showing the estimated strontium–90 and cesium–137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modification to the isograms are made according to available information on milksheds.

In order to develop the distribution of the network's stations versus radionuclide concentrations in milk, table 3 has been prepared using monthly averages shown in table 2.

Continuing the practice followed in previous issues of *RHD*, the average monthly strontium–90 concentrations in pasteurized milk from 16 selected cities in the sampling program are presented in figure 3. Each graph shows the strontium–90 concentrations in milk from one city in each of the four U. S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a year. The last column in table 2 shows the most recent issue in which a graph of the strontium–90 concentration was given for each station. A tabulation of the network monthly maximum, minimum, and average radionuclide concentration in milk was given for March 1960–March 1964 in the July 1964 issue of *RHD*.

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

[2] The conversion factor is 1.18 x 10^{-3} g K/pc K^{40}.

Table 2.—STABLE ELEMENT AND RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, APRIL 1964 [a]

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (g/liter)		Potassium (g/liter)		Strontium-89		Strontium-90		Cesium-137		Last Sr^{90} graph in *RHD* (1964)
		First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	
Ala:	Montgomery	1.19	1.15	1.5	1.4	<5	<5	24	26	100	95	June
Alaska:	Palmer	1.16	1.25	1.5	1.5	10	10	23	20	160	155	July
Ariz:	Phoenix	1.18	1.17	1.5	1.4	<5	<5	4	8	25	35	May
Ark:	Little Rock	1.18	1.15	1.5	1.5	<5	5	43	56	165	170	July
Calif:	Sacramento	1.25	1.23	1.6	1.5	<5	<5	11	12	65	60	August
	San Francisco	1.23	1.22	1.5	1.4	<5	5	13	16	75	65	June
Canal Zone:	Cristobal	1.13	1.08	1.6	1.5	<5	<5	6	6	50	55	July
Colo:	Denver	1.23	1.28	1.6	1.6	<5	5	19	21	90	95	August
Conn:	Hartford	1.15	1.11	1.6	1.4	<5	<5	23	22	185	175	August
Del:	Wilmington	1.21	1.21	1.6	1.5	<5	<5	21	28	150	155	May
D. C:	Washington	1.17	1.12	1.6	1.6	<5	<5	18	21	105	110	June
Fla:	Tampa	1.21	1.12	1.5	1.5	<5	<5	15	17	200	240	May
Ga:	Atlanta	1.21	1.17	1.6	1.5	<5	<5	35	37	160	180	June
Hawaii:	Honolulu	1.18	1.13	1.6	1.6	<5	<5	11	12	80	80	July
Idaho:	Idaho Falls	1.19	1.18	1.6	1.3	5	10	27	40	220	230	May
Ill:	Chicago	1.18	1.22	1.6	1.6	<5	<5	21	18	145	145	June
Ind:	Indianapolis	1.22	1.22	1.6	1.5	<5	<5	22	20	120	120	August
Iowa:	Des Moines	1.22	1.26	1.5	1.4	<5	10	27	27	110	110	May
Kans:	Wichita	1.21	1.19	1.5	1.4	10	5	23	18	80	80	July
Ky:	Louisville	1.18	1.16	1.6	1.5	<5	<5	32	37	125	125	May
La:	New Orleans	1.22	1.18	1.5	1.5	<5	<5	54	66	165	205	July
Maine:	Portland	1.20	1.18	1.6	1.6	<5	<5	31	30	220	205	May
Md:	Baltimore	1.17	1.13	1.5	1.6	<5	<5	20	22	115	135	May
Mass:	Boston	1.20	1.20	1.6	1.6	<5	<5	32	32	265	255	June
Mich:	Detroit	1.19	1.20	1.6	1.5	<5	<5	19	19	135	130	August
	Grand Rapids	1.21	1.23	1.5	1.5	<5	<5	22	19	145	140	May
Minn:	Minneapolis	1.18	1.24	1.6	1.5	10	10	35	30	190	160	June
Miss:	Jackson	1.26	1.22	1.5	1.4	5	<5	41	60	125	140	August
Mo:	Kansas City	1.22	1.19	1.5	1.4	5	10	28	30	100	110	August
	St. Louis	1.20	1.23	1.5	1.4	5	10	23	26	100	100	July
Mont:	Helena	1.22	1.19	1.5	1.4	10	15	31	29	235	225	July
Nebr:	Omaha	1.21	1.14	1.5	1.4	5	5	25	28	105	120	May
Nev:	Las Vegas	1.24	1.18	1.6	1.5	<5	<5	15	6	95	90	June
N. H:	Manchester	1.22	1.20	1.7	1.6	<5	<5	32	30	260	265	May
N. J:	Trenton	1.19	1.18	1.6	1.6	5	<5	18	18	140	140	August
N. Mex:	Albuquerque	1.19	1.23	1.5	1.4	<5	10	12	17	60	90	July
N. Y:	Buffalo	1.16	1.16	1.6	1.6	<5	<5	20	22	170	170	August
	New York	1.16	1.16	1.6	1.5	<5	<5	25	25	190	195	June
	Syracuse	1.18	1.14	1.6	1.6	<5	<5	22	21	170	165	July
N. C:	Charlotte	1.22	1.15	1.5	1.4	<5	<5	31	37	115	125	July
N. Dak:	Minot	1.21	1.22	1.5	1.5	15	10	58	62	160	165	May
Ohio:	Cincinnati	1.21	1.18	1.6	1.5	<5	<5	24	27	125	120	August
	Cleveland	1.21	1.18	1.6	1.5	<5	<5	22	19	135	140	July
Okla:	Oklahoma City	1.18	1.13	1.6	1.6	<5	<5	25	27	90	80	June
Ore:	Portland	1.24	1.26	1.5	1.5	5	10	27	36	155	185	August
Pa:	Philadelphia	1.21	1.19	1.6	1.5	<5	<5	20	22	145	150	July
	Pittsburgh	1.19	1.16	1.6	1.5	<5	<5	28	28	170	180	July
P. R:	San Juan	1.16	1.10	1.6	1.6	<5	<5	12	16	70	100	July
R. I:	Providence	1.18	1.16	1.6	1.6	<5	<5	25	24	185	180	May
S. C:	Charleston	1.18	1.17	1.5	1.5	<5	<5	34	35	135	140	August
S. Dak:	Rapid City	1.19	1.01	1.5	1.5	10	5	38	35	175	145	June
Tenn:	Chattanooga	1.23	1.18	1.5	1.4	5	<5	38	54	145	165	June
	Memphis	1.21	1.16	1.5	1.5	<5	<5	32	42	90	85	May
Tex:	Austin	1.17	1.09	1.6	1.6	<5	<5	10	9	45	40	June
	Dallas	1.19	1.12	1.6	1.5	<5	<5	22	22	85	70	August
Utah:	Salt Lake City	1.21	1.25	1.5	1.4	5	5	27	32	215	225	July
Vt:	Burlington	1.18	1.20	1.6	1.5	<5	<5	26	25	210	210	August
Va:	Norfolk	1.18	1.13	1.6	1.6	<5	<5	20	24	105	105	August
Wash:	Seattle	1.21	1.22	1.5	1.5	10	10	21	24	120	110	June
	Spokane	1.24	1.30	1.6	1.4	5	10	33	27	145	165	August
W. Va:	Charleston	1.18	1.11	1.5	1.5	<5	<5	26	28	110	105	June
Wis:	Milwaukee	1.22	1.24	1.7	1.6	<5	<5	19	21	160	160	May
Wyo:	Laramie	1.18	1.25	1.5	1.4	10	20	21	22	115	115	May
Network average		1.20	1.18	1.6	1.5	<5	<5	24.8	26.8	136	140	Nov. 63

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[a] The monthly average iodine-131 and barium-140 concentration at each station was <10 pc/liter.

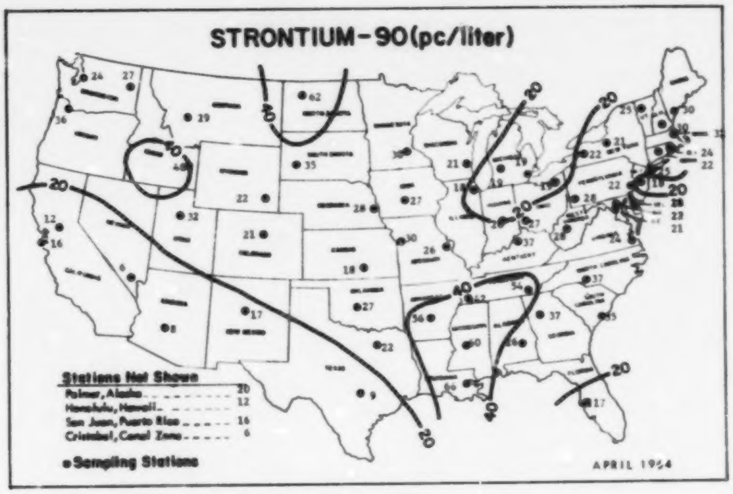
STRONTIUM-90(pc/liter)
Stations Not Shown
Palmer, Alaska - - - - - 20
Honolulu, Hawaii - - - - - 12
San Juan, Puerto Rico - - - - 16
Cristobal, Canal Zone - - - - 6
● Sampling Stations
APRIL 1964

FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, APRIL 1964

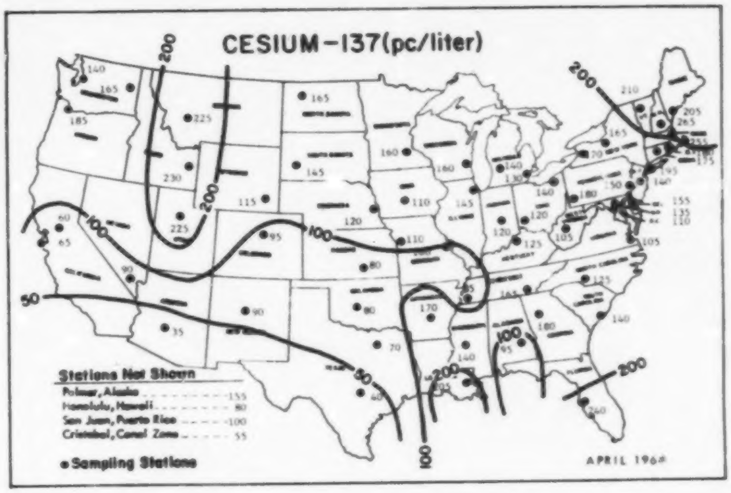
CESIUM-137(pc/liter)
Stations Not Shown
Palmer, Alaska - - - - - 155
Honolulu, Hawaii - - - - - 80
San Juan, Puerto Rico - - - - 100
Cristobal, Canal Zone - - - - 55
● Sampling Stations
APRIL 1964

FIGURE 2.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK, APRIL 1964

TABLE 3.—DISTRIBUTION OF SAMPLING STATIONS IN VARIOUS RANGES OF RADIONUCLIDE CONCENTRATIONS IN MILK, APRIL 1964

Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
(pc/liter)	Number of stations	(pc/liter)	Number of stations	(pc/liter)	Number of stations	(pc/liter)	Number of stations	(pc/liter)	Number of stations
<5	43	<1-9	4	<10	63	<5-45	2	<10	63
5	7	10-14	2			50-95	12		
10	11	15-19	10			100-145	23		
15	1	20-24	15			150-195	17		
20	1	25-29	13			200-245	7		
		30-34	6			250-295	2		
		35-39	6						
		40-69	7						

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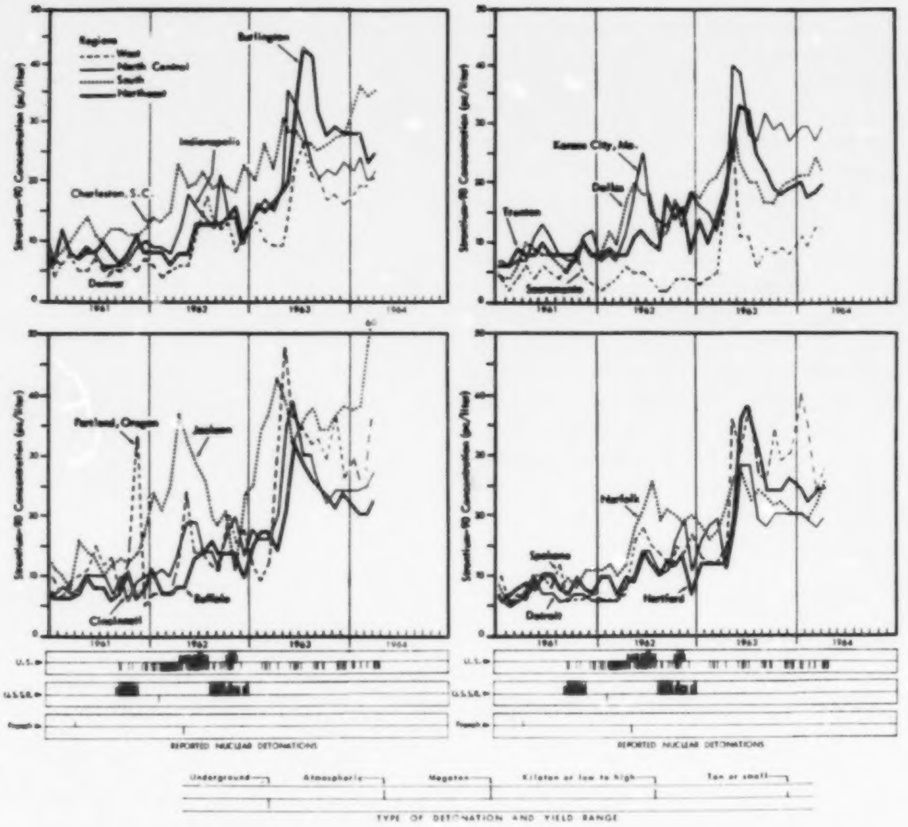

FIGURE 3.—STRONTIUM-90 IN PASTEURIZED MILK, 1961–APRIL 1964

2. Indiana Milk Network
April 1964

Bureau of Environmental Sanitation,
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analysis in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (figure 4).

The milk samples are routinely analyzed for iodine–131, cesium–137, barium–140, strontium–89 and strontium–90. Until August 1963, analyses for the gamma emitters iodine–131, cesium–137 and barium–140 were conducted on a weekly basis, except when iodine–131 exceeded 100 pc/liter, at which times the frequency of sampling was increased. Because of continued low concentrations of the short-lived gamma emitters, the sampling frequency was reduced in August 1963 to once per month for the northeast, southeast and southwest milksheds. Strontium–89 and strontium–90 analyses are performed monthly for each station.

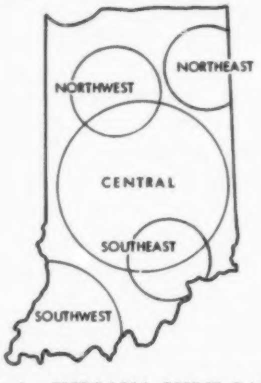

FIGURE 4.—INDIANA MILK SAMPLING LOCATIONS

An ion exchange analytical procedure (*3*) is employed for strontium–89 and strontium–90 analyses. Minimum detectable levels for strontium–89 and strontium–90 are about 5 and 1 pc/liter, respectively. A 512–channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine–131, cesium–137, and barium–140. Analyses of counting statistics indicate that the lower limit of detectability for both iodine–131 and barium–140 is 5 pc/liter. Cesium–137 analyses are subject to a 6 percent error at the 100 pc/liter level. Additional factors such as drift of the analyzer and calibration factors will increase these limits to some extent.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 4. The State average is an arithmetic average of the station values.

Table 4.—RADIONUCLIDES IN INDIANA MILK, APRIL 1964 [a]

[Radionuclide concentrations in pc/liter]

Sampling location	Calcium (g/liter)	K^{40}	Sr^{90}	Cs^{137}
Northeast	1.14	1,420	17	115
Southeast	1.14	1,470	18	110
Central	1.14	1,410	18	115
Southwest	1.10	1,600	17	90
Northwest	1.14	1,400	17	130
Average	1.13	1,460	17	110

[a] The monthly average iodine-131, strontium-89, and barium-140 concentrations at each station were zero.

3. New York Milk Network
February 1964

Division of Environmental Health Services, State of New York Department of Health

Milk samples collected routinely from six cities—Albany, Buffalo, Massena, Newburg, New York City, and Syracuse (figure 5) are analyzed for their radionuclide content by the State of New York Department of Health. Pasteurized milk samples are collected daily and composited weekly for the determination of strontium–89, strontium–90, iodine–131, cesium–137 and barium–lanthanum–140 at all stations except Massena, where samples are composited bi-weekly, and at New York City where one daily milk sample representing the total milk supply for that day is obtained and analyzed once per week. Samples are obtained from processing plants except at Albany, where the daily sample is obtained from a marketing point. During periods when cows are no longer on stored feed, the sample from Albany is analyzed daily for iodine–131. In the event that any city reports iodine–131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken.

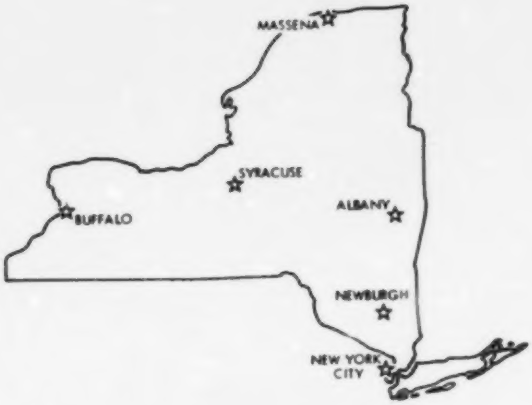

Figure 5.—NEW YORK MILK SAMPLING LOCATIONS

A matrix method (*4*) is used for the analysis of spectral data to determine the concentrations of gamma-emitting nuclides in milk. With this method, the individual nuclide contributions to the gamma spectrum are separated by solution of simultaneous equations describing the spectral interferences.

The analytical procedure for strontium–89 and strontium–90 is based on ion exchange methods. Cations (including radiostrontium) are eluted from the ion exchange resin with sodium chloride solution, strontium isotopes are gathered by means of sodium carbonate, isolated by means of ethylenediaminetetraacetic acid (EDTA), and radiostrontium is counted with a low background beta counter having an 0.8 mg/cm^2 window. The strontium–90 portion is differentially estimated by a second count 40 hours later to determine the rate of in-growth of its daughter product yttrium–90. The monthly average radionuclide concentrations in milk are shown in table 5.

TABLE 5.—RADIONUCLIDES IN NEW YORK MILK, FEBRUARY 1964 [a]

[Average concentrations in pc/liter]

Sampling location	Strontium-89	Strontium-90	Cesium-137
Albany	4	17	124
Buffalo	4	10	92
Massena	6	32	208
Newburgh	6	16	135
New York City	5	21	131
Syracuse	<3	21	121
Average	5	20	135

Note: Ba-La^{140} refers to the sum of these two nuclides in equilibrium.

[a] The monthly average I^{131} and Ba-La^{140} at each station was <20 pc/liter.

4. Canadian Milk Network[3]
April 1964

Radiation Protection Division
Department of National Health and Welfare,
Ottawa, Canada

The Radiation Protective Division of the Department of National Health and Welfare began monitoring milk for strontium–90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963, liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and in addition it is possible to choose milk sampling locations (see figure 6) in the same areas as the air and precipitation stations. At present, the analyses include determination of iodine–131, strontium–89, cesium–137 and strontium–90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies and are combined into weekly composites and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine–131. The results of the spot checks for iodine–131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium–90, strontium–89, cesium–137, and stable potassium and calcium.

Analytical Methods

Radiochemical methods are used for the analysis of iodine–131 (5). For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet and evaporated under infra-red lamps. The residue is ashed in a muffle furnace at 450°C, dissolved in dilute nitric acid, and strontium separated by fuming nitric acid precipitation. The combined strontium–89 and strontium–90 are determined by counting in a low background beta counter. Strontium–90 is determined separately by extracting and counting the yttrium–90 daughter nuclide while strontium–89 is

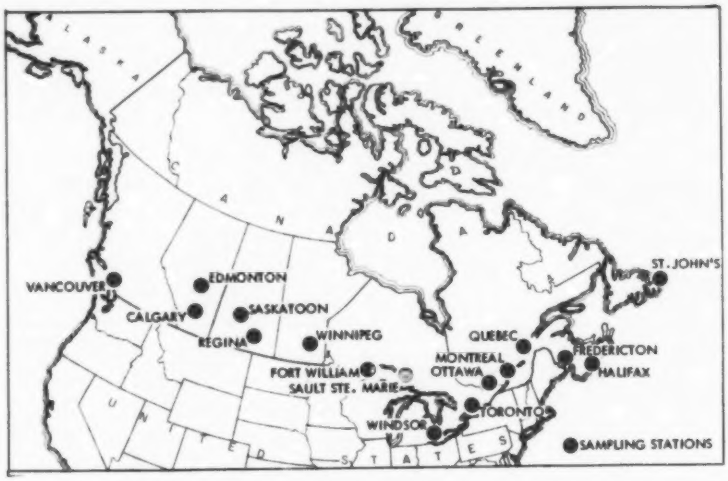

FIGURE 6.—CANADIAN MILK SAMPLING STATIONS

estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

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[3] Data from Radiation Protection Programs, Vol. 2, No. 5: 25-29, Radiation Protection Division, Canadian Department of National Health and Welfare (May 1964).

Cesium-137 is determined by gamma spectroscopy using a scintillation crystal and a multi-channel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium-40 and cesium-137 content of the milk by comparison of the spectrum with standard preparations. The stable potassium content is estimated from the potassium-40 concentration.

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the determination of cesium-137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 6.

TABLE 6.—TOTAL ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS IN MILK[a]

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Strontium-89	±25%	±20%	±15%
Strontium-90	±15%	±10%	±10%
Iodine-131	±50%	±20%	±10%
Cesium-137	±60%	±25%	±10%

[a] All errors are 2σ values, representing 95 percent confidence.

Results

Table 7 presents monthly averages of strontium-90, cesium-137 and stable calcium and potassium in Canadian whole milk. Spot checks for iodine-131 and strontium-89 indicate that all samples had <5 pc/liter.

TABLE 7.—RADIONUCLIDES IN CANADIAN WHOLE MILK, APRIL 1964

[Radionuclide concentrations in pc/liter]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90	Cesium-137
Calgary	1.34	1.5	46.2	286
Edmonton	1.41	1.5	35.1	222
Ft. William	1.33	1.6	57.8	310
Fredericton	1.46	1.7	49.9	349
Halifax	1.41	1.6	37.7	270
Montreal	1.40	1.7	37.2	277
Ottawa	1.35	1.7	32.9	227
Quebec	1.34	1.6	49.3	322
Regina	1.31	1.6	52.1	212
St. John's, Nfld	1.40	1.6	44.1	266
Saskatoon	1.34	1.6	59.6	229
Sault Ste. Marie	1.33	1.6	37.9	202
Toronto	1.40	1.6	18.9	137
Vancouver	1.46	1.5	42.7	271
Windsor	1.44	1.6	17.0	114
Winnipeg	1.31	1.6	44.9	234
Average	1.38	1.6	41.5	246

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(*3*) Porter, C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determination of Strontium-90 in Milk by an Ion Exchange Method, *Analytical Chemistry, 33:* 1306–8 (September 1961).

(*4*) Kahn, B., *et al.*: *Rapid Methods for Estimating Fission Product Concentrations in Milk, Public Health Service Publication No. 999–R–2,* (March 1963). Single copies available on request from Public Inquiries Branch, PHS, U.S. Department of Health, Education, and Welfare, Washington D. C. 20201.

(*5*) DasGupta, A. K., and H. G. Green: *A Method for the Radiochemical Determination of Iodine-131 in Milk, RPD-23,* Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada (October 1963).

MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, MAY 1963—APRIL 1964

Division of Radiological Health, Public Health Service

Radionuclide concentration values reported by the Pasteurized Milk Network (*1*) can be used to estimate the contribution of milk to a population's radiation exposure. This is done by determining both the annual average concentrations of specific radionuclides in milk and the average daily milk consumption of a representative individual in a suitable sample of the population.

The data listed in table 1 are concerned with the first of these requirements, *i.e.*, annual average concentrations of strontium-89, strontium-90, and cesium-137 in one liter of pasteurized milk. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U. S. population (*2,3*).

To arrive at a basis of comparison between the daily rates of intake of the radionuclides from the milk component of the diet and the Federal Radiation Council's ranges of transient daily rates of intake (*4*), it is assumed that the average daily milk consumption of an individual in a population group is one liter. The Guides, however, apply to total intake from all sources. The upper limits of Range II correspond to the Radiation Protection Guide (RPG) for iodine-131 and to one-third of the Radiation Protection Guide for radioactive strontium. The Guides are, for administrative reasons, expressed as a yearly radiation dose, but are based on lifetime exposure (*5*). The FRC emphasizes that the annual acceptable risk or exposure dose is not a dividing line between safety and danger in actual radiation situations (*6*).

Annual averages of radionuclide concentrations in milk sampled by the PHS Pasteurized Milk Network are presented in table 1. The data in table 1 are calculated as follows: Results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of twelve consecutive months are averaged to obtain the annual average.[1] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk (*3,4*).

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as weather conditions and dairying practices. The moving yearly average (table 1), obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

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(*1*) Public Health Service: Milk Surveillance—Pasteurized Milk Network, *Radiological Health Data, 5*:57-61 (February 1964).

(*2*) Bureau of the Census, and Public Health Service: National Food Consumption Survey, Fresh Whole Milk Consumption in the United States, July 1962, *Radiological Health Data 4*: 15-17 (January 1963).

(*3*) Bureau of the Census and Public Health Service: Consumption of Selected Food Items in U. S. Households, July 1962, *Radiological Health Data, 4:* 124-7.

(*4*) Federal Radiation Council: Radiation Protection Guidance for Federal Agencies, *Federal Register: 9957-8*, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (September 26, 1961).

(*5*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents U. S. Government Printing Office, Washington, D. C. 20402 (September 1961). Price 20 cents.

(*6*) Public Health Service: Special Report, *Radiological Health Data, 3: ii-iii*, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (September 1962).

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[1] Beginning with the October 1963 data, iodine-131 values of <10 pc/liter are considered to be zero for averaging purposes; previously, 5 pc/liter was used for calculating the averages.

TABLE 1.—MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK[a]

[Concentrations in pc/liter]

Sampling locations		Strontium-89		Strontium-90		Cesium-137	
		April 1963—March 1964	May 1963—April 1964	April 1963—March 1964	May 1963—April 1964	April 1963—March 1964	May 1963—April 1964
Ala:	Montgomery	38	31	22	23	89	91
Alaska:	Palmer	28	27	24	24	140	149
Ariz:	Phoenix	8	6	4	4	22	24
Ark:	Little Rock	80	64	44	45	166	168
Calif:	Sacramento	32	21	11	11	66	65
	San Francisco	50	31	14	13	79	75
Colo:	Denver	23	22	18	19	90	93
Conn:	Hartford	21	21	26	26	173	182
Del:	Wilmington	27	25	26	27	141	148
D. C:	Wasnington	37	33	20	20	105	106
Fla:	Tampa	18	15	15	15	231	235
Ga:	Atlanta	58	49	32	33	156	161
Hawaii:	Honolulu	0	16	11	11	79	82
Idaho:	Idaho Falls	48	47	27	30	167	178
Ill:	Chicago	18	18	21	21	120	125
Ind:	Indianapolis	26	24	24	24	108	112
Iowa:	Des Moines	54	51	28	28	98	102
Kans:	Wichita	37	35	22	22	78	80
Ky:	Louisville	76	65	35	35	121	125
La:	New Orleans	68	51	46	47	158	162
Maine:	Portland	26	26	33	34	220	228
Md	Baltimore	45	42	22	23	129	133
Mass:	Boston	31	31	36	37	248	261
Mich:	Detroit	16	15	20	21	119	124
	Grand Rapids	17	16	21	22	127	132
Minn:	Minneapolis	47	47	33	34	161	166
Miss:	Jackson	69	53	37	39	119	121
Mo:	Kansas City	60	56	30	31	91	96
	St. Louis	43	41	24	25	93	96
Mont:	Helena	43	43	30	31	195	207
Nebr:	Omaha	45	44	27	28	103	107
Nev:	Las Vegas	15	14	11	11	77	81
N. H:	Manchester	29	28	35	36	268	280
N. J:	Trenton	21	21	22	22	132	138
N. Mex:	Albuquerque	17	16	11	12	49	54
N. Y:	Buffalo	21	21	23	24	149	156
	New York	29	29	31	31	178	188
	Syracuse	24	24	25	25	148	156
N. C:	Charlotte	58	50	33	34	128	131
N. Dak:	Minot	81	80	55	58	150	157
Ohio:	Cincinnati	32	27	27	28	101	105
	Cleveland	23	22	23	23	117	123
Okla:	Oklahoma City	48	41	24	24	93	93
Ore:	Portland	60	50	32	33	171	177
Pa:	Philadelphia	25	24	24	24	134	140
	Pittsburgh	32	31	30	31	160	168
P. R:	San Juan	36	25	14	13	89	88
R. I:	Providence	25	23	29	29	178	186
S. C:	Charleston	38	32	29	29	133	136
S. Dak:	Rapid City	61	59	42	43	164	170
Tenn:	Chattanooga	82	68	40	42	154	158
	Memphis	62	51	33	33	93	95
Tex:	Austin	19	14	10	9	49	48
	Dallas	42	32	21	21	84	84
Utah:	Salt Lake City	31	30	26	27	174	186
Vt:	Burlington	25	25	29	30	193	203
Va:	Norfolk	37	31	22	23	108	109
Wash:	Seattle	50	45	27	27	157	161
	Spokane	47	45	30	31	147	154
W. Va:	Charleston	61	55	31	31	108	110
Wis:	Milwaukee	17	16	20	21	129	136
Wyo:	Laramie	35	35	23	24	119	120
Network average		39	34	26.0	26.6	131	136

[a] Annual averages were computed on basis of 52 weekly averages.

78

QUALITY CONTROL CROSS-CHECK ANALYSES OF GAMMA EMITTERS IN MILK, DIVISION OF RADIOLOGICAL HEALTH, APRIL—OCTOBER, 1963

Marvin Rosenstein, Kenneth H. Falter, and Abraham S. Goldin[1]

In the initial report (*1*) of the Analytical Quality Control Service (AQCS), the objectives and operations of the overall program, along with the fundamental means of meeting these objectives, were reviewed. Included also were the data from the first two technical experiments[2] on the determination of iodine-131 in milk showing that individual analyses can be performed with an accuracy of ±10 percent. Among the other activities of AQCS described in that report was the distribution of natural environmental samples for cross-check purposes. Such a program has been in operation in one form or another for fluid milk for several years. In this report, data on the analysis of gamma emitters covering the period April 1963 through October 1963 are presented and discussed.

Distribution and Analysis of Samples

Analyses of milk for radionuclides and stable elements are performed routinely in three Division of Radiological Health laboratories, located in Las Vegas, Nevada; Montgomery, Alabama; and Winchester, Massachusetts. In addition to these laboratories, which carry the bulk of the Pasteurized Milk Network analytical load, the Division's laboratory at Honolulu and the Milk and Food Laboratory (Division of Environmental Engineering and Food Protection) at Cincinnati, Ohio, were included in this study. The primary purpose of the program is to check the agreement among these several laboratories.

During the period April through October 1963 each participating laboratory analyzed two cross-check samples in triplicate each month. The concentrations of I^{131}, Ba^{140}, Cs^{137}, and potassium in each sample were measured at each laboratory by gamma scintillation spectroscopy.[3] Values were reported to the nearest picocurie per liter or for potassium to the nearest 0.01 gram per liter. The program thus provided a measure of the degree to which the laboratories results agreed with each other.

Data obtained through the internal quality control programs at each laboratory, while not discussed in this report, have demonstrated acceptable internal precision, which is a necessary condition before the cross-check intercomparisons can be made. The monthly cross-checks thus complement intralaboratory quality control and the analysis of samples of known concentration. This cross-check program has made possible the continuous quality control monitoring of all gamma spectroscopic analyses of milk samples and has provided a greater volume of data on actual environmental samples than could be obtained through a series of technical experiments. Corrective action taken as a result of the information obtained from technical experiments is also reflected in improvement and maintenance of laboratory agreement in the cross-check program.

Procedure

Tables 1–4 give the date of the sample, the mean of triplicate analyses from each laboratory, the observed range between the largest and smallest values of the laboratory means, and the allowable range calculated as analytically acceptable and attainable for I^{131}, Ba^{140}, Cs^{137}, and potassium. The observed laboratory range is utilized to determine the agreement among laboratories. This agreement is measured by comparison of the range between laboratory values with predetermined acceptable ranges. Statistically, the range is almost as efficient a measurement of dispersion as the standard deviation when the range is calculated from a set of data in which the number of results in the set are small (*2*).

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[1] Mr. Rosenstein is Program Coordinator and Dr. Goldin is Director of the Analytical Quality Control Service of the Division of Radiological Health, located at the Northeastern Radiological Health Laboratory, Winchester, Massachusetts. Mr. Falter is Assistant Chief, Biometrics Unit, Research Branch, Division of Radiological Health, Public Health Service, U.S. Department of Health, Education and Welfare, Washington 25, D. C.

[2] A technical experiment, as defined by AQCS, is the analysis and interpretation of data obtained from the determination, by participating laboratories, of a single nuclide present in a known concentration in a suitable matrix.

[3] The determination of Ba^{140} at one laboratory is done by radiochemistry and the determination of potassium at another laboratory is done by flame photometry.

The allowable ranges are calculated from assigned standard deviations using factors from statistical tables (*3*). These ranges depend on the concentration of the nuclide or element under consideration, the number of replicates, and the number of laboratories returning results. They specify a value which 97.5 percent of all observed concentrations ranges should not exceed when analytical specifications are being met.

The allowable ranges are calculated as follows:

1. Standard deviation values for individual determinations are selected on the basis of the capabilities of the analytical measurements and on the requirements for agreement in the determinations. For the radionuclides I^{131}, Ba^{140}, and Cs^{137} the standard deviation for levels ≤ 100 pc/liter is $\pm$ 5 pc/liter, and for levels >100 pc/liter it is $\pm$ 5 percent.
   The standard deviation for stable potassium is $\pm$ 0.06 gm/liter for all levels in milk.
2. The standard deviation for means (σ_m), for each radionuclide or element is calculated by dividing the assigned standdard deviation for individual values (σ) by the square root of the number of replicate determinations, in this case three:

   $$\sigma_m = \frac{\sigma}{\sqrt{3}}$$

   The values for σ_m are:
   I^{131}, Ba^{140}, Cs^{137}
   $\pm$ 2.9 pc/liter for levels ≤ 100 pc/liter;
   $\pm$ 2.9 percent for levels >100 pc/liter
   K $\pm$ 0.035 gm/liter for all levels
3. Using the above standard deviations for means (σ_m), the allowable range for each nuclide or element is calculated from the following relationship:

   $$\text{Allowable Range} = D\,\sigma_m$$

   where D = factor, determined from statistical tables (*3*), as a function of the number of laboratory means and the statistical confidence level chosen. The number of laboratory means in this study was from three to five, depending on the number of laboratories returning results. A confidence limit equivalent to a "two-sigma" level was used in all cases.
4. A chart can subsequently be prepared showing the allowable range of the laboratory means. This range defines a level which 97.5 percent of observed ranges *should not exceed*, since the upper "two-sigma" limit excludes 2.5 percent of the distribution. In the chart the allowable range is shown as a function of the level being measured and the number of laboratories involved. A sample of such a chart for I^{131}, Ba^{140}, and Cs^{137} is shown in figure 1.

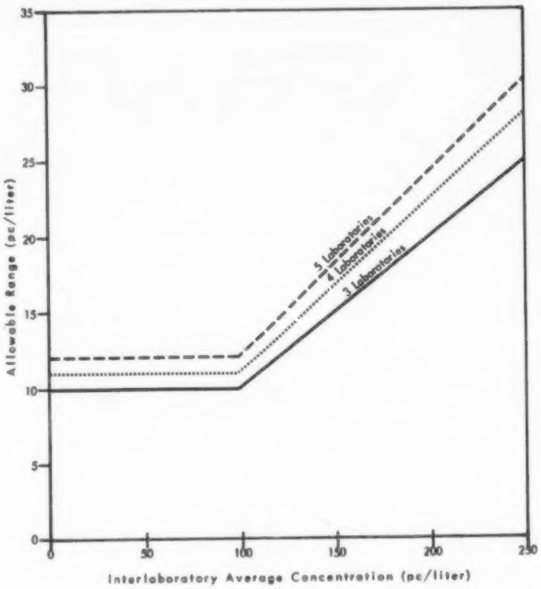


FIGURE 1.—ACCEPTABLE RANGE OF LABORATORY MEANS AT THE 2σ CONFIDENCE LEVEL VERSUS AVERAGE I^{131}, Ba^{140}, OR Cs^{137} CONCENTRATIONS IN MILK SAMPLES

In the final analysis, observed ranges that are greater than the allowable range indicate that the laboratories do not agree with each other within the standard deviation (σ) chosen as acceptable. When the agreement is not acceptable, it may be because the result from one laboratory was erratic or because the overall spread of the results was excessive, without being attributable to any one laboratory.

Discussion of Results

In the following discussion, it should be remembered that the data presented here are restricted to the period April–October 1963, and to the levels present in the samples. The conclusions presented here should not be extrapolated to other periods, other laboratories, or other levels.

Iodine–131: The data in table 1 indicate that there was good agreement among the laboratories for I^{131} analyses by gamma spectroscopy. In every case during the April–October 1963 period the levels of I^{131} in the milk samples distributed were very low, approaching 0 pc/liter. In each of the three cases where the agreement was not acceptable (samples 3, 11 and 12) a single laboratory (not the same one each time) reported results higher than the others. The results, while of interest analytically, were not large deviations. Therefore, the I^{131} results, in general, substantiate the findings of the first AQCS report (*1*), that I^{131} analyses were performed with an acceptable degree of analytical control.

Barium–140: The data in table 2 indicate that there was good agreement among the laboratories for Ba^{140} analyses. Barium–140 is determined in four of the five laboratories by gamma spectroscopy and in the fifth laboratory (laboratory B) by a radiochemical procedure. Again, in all cases during the April–October 1963 period, the levels of Ba^{140} in the milk samples distributed were very low, approaching 0 pc/liter. In three samples (samples 12, 13 and 14) laboratory B appeared to

TABLE 1.—MEAN IODINE-131 CONCENTRATIONS IN MILK CROSS-CHECK SAMPLES

[Concentrations in pc/liter]

Sample identification and date (1963)	Laboratory					Observed range	Allowable range
	A	B	C	D	E		
October							
#1	2.6	6.7	8.0	0.0	3.7	8.0	11.7
#2	9.5	5.3	5.7	0.0	4.0	9.5	11.7
September							
#3	4.7	1.0	13.7	0.0	2.3	[a] 13.7	11.7
#4	2.3	6.3	10.3	0.0	1.0	10.3	11.7
August							
#5	0.0	2.7	[b] —	0.0	8.7	8.7	10.9
#6	2.0	10.3	0.0	0.0	1.3	10.3	11.7
July							
#7	0.3	7.7	9.0	0.0	4.3	9.0	11.7
#8	0.0	2.3	2.3	0.0	6.0	6.0	11.7
June							
#9	1.0	6.3	1.7	1.3	0.0	6.3	11.7
#10	—	4.7	6.0	0.0	3.7	6.0	10.9
May							
#11	4.7	7.3	6.0	0.0	12.3	[a] 12.3	11.7
#12	2.0	14.3	5.7	0.0	3.0	[a] 14.3	11.7
April							
#[illegible]	6.3	7.3	6.0	4.7	6.0	2.6	11.7
[illegible]	3.3	10.3	1.3	1.0	10.3	9.3	11.7

[a] Observed range is greater than allowable range.
[b] Dash indicates no analysis performed.

be obtaining higher results than the other laboratories. However, the remaining data indicate that this discrepancy had been corrected as the result of a modification of the radiochemical procedure. These results, therefore, demonstrate that Ba^{140} analyses were performed with an acceptable degree of analytical control. They also incidentally demonstrate that satisfactory agreement was obtained although radically different analytical techniques were employed.

TABLE 2.—MEAN BARIUM-140 CONCENTRATIONS IN MILK CROSS-CHECK SAMPLES

[Concentrations in pc/liter]

Sample identification and date (1963)	Laboratory					Observed range	Allowable range
	A	B	C	D	E		
October							
#1	0.0	3.3	8.7	0.0	0.0	8.7	11.7
#2	0.0	3.7	2.3	0.0	[a] —	3.7	10.9
September							
#3	0.0	3.7	8.7	0.0	0.0	8.7	11.7
#4	4.7	3.7	3.7	0.0	0.0	4.7	11.7
August							
#5	0.7	5.0	—	0.0	0.0	5.0	10.9
#6	5.3	5.3	0.0	2.7	0.0	5.3	11.7
July							
#7	0.0	3.7	10.0	0.0	0.3	10.0	11.7
#8	1.3	3.3	5.7	2.3	0.0	5.7	11.7
June							
#9	2.7	8.7	7.3	0.0	0.0	8.7	11.7
#10	—	7.7	4.7	0.0	0.0	7.7	10.9
May							
#11	0.0	8.0	6.0	0.0	5.0	8.0	11.7
#12	2.3	16.7	4.7	0.0	5.0	[b] 16.7	11.7
April							
#13	3.3	14.0	6.7	0.0	10.0	[b] 14.0	11.7
#14	0.7	16.0	3.0	0.0	0.0	[b] 16.0	11.7

[a] Dash indicates no analysis performed.
[b] Observed range greater than the allowable range.

Cesium-137: The application of cross-check analyses to uncover disagreement among laboratories is illustrated nicely for the Cs^{137} analyses in milk during the April–October 1963 period. The data (table 3) from the ten samples from April–August 1963 show that whenever the Cs^{137} level was greater than 70 to 75 pc/liter (seven of the ten cases), the observed range was greater than the allowable range and in some cases extremely large (6 and 10). In all seven of these cases, either laboratory A, B, or both yielded results higher than the other laboratories. During June, 1963, a milk sample, containing a known amount of Cs^{137}, was distributed to all five participating laboratories to determine which laboratories were yielding accurate data and which laboratories were yielding biased data. As a result of that study, completed in September 1963, laboratories A and B recalibrated their gamma spectrometers with a standardized Cs^{137} solution. The data in table 3 for September-October 1963 indicate the resulting improvement. The observed range for sample number 3, while slightly larger than expected, is not particularly high. Data obtained since October 1963 (not included in table 3) further substantiate this improvement.

TABLE 3.—MEAN CESIUM-137 CONCENTRATIONS IN MILK CROSS-CHECK SAMPLES

[Concentrations in pc/liter]

Sample identification and date (1963)	Laboratory					Observed range	Allowable range
	A	B	C	D	E		
October							
#1	76.4	68.7	72.3	72.3	68.3	8.1	11.7
#2	51.0	46.3	51.0	49.0	43.7	7.3	11.7
September							
#3	94.7	82.3	89.3	92.3	86.7	[a] 12.4	11.7
#4	257.0	255.3	239.3	250.0	248.3	17.7	27.8
August							
#5	140.0	121.0	[b] —	132.0	124.0	[a] 19.0	14.3
#6	271.0	220.0	209.0	234.7	220.3	[a] 62.0	26.6
July							
#7	272.3	278.3	247.3	250.7	256.3	[a] 31.0	30.0
#8	125.3	146.0	132.0	132.7	131.0	[a] 20.7	15.6
June							
#9	58.3	63.0	60.3	65.3	63.3	7.0	11.7
#10	—	121.0	99.0	110.0	110.7	[a] 22.0	12.0
May							
#11	71.0	66.3	61.0	63.0	62.0	10.0	11.7
#12	85.3	90.3	78.3	76.3	76.7	[a] 14.0	11.7
April							
#13	37.7	39.3	32.3	35.3	31.0	8.3	11.7
#14	81.7	91.7	75.0	75.7	78.3	[a] 16.7	11.7

[a] Observed range greater than allowable range.
[b] Dash indicates no analysis performed.

Potassium: Potassium is determined in four of the five laboratories by gamma spectroscopy and in the fifth by flame photometry. The potassium content in milk is fairly constant, usually between 1.40 and 1.60 gm/liter. The data given in table 4 indicate potassium analyses were not performed with the desired degree of analytical control; in every case during the April–October 1963 period the observed range was larger than the allowable range. While potassium analyses are

TABLE 4.—MEAN POTASSIUM CONCENTRATIONS IN MILK CROSS-CHECK SAMPLES

[Concentrations in g/liter]

Sample identification and date (1963)	Laboratory					Observed range	Allowable range
	A	B	C	D	E		
October							
#1	1.61	1.43	1.64	1.43	1.58	[a] 0.21	0.14
#2	1.63	1.45	1.64	1.50	1.61	[a] 0.19	0.14
September							
#3	1.60	1.39	1.77	1.54	1.56	[a] 0.38	0.14
#4	1.64	1.46	1.58	1.57	1.50	[a] 0.18	0.14
August							
#5	1.64	1.24	[b] —	1.81	1.65	[a] 0.57	0.13
#6	1.80	1.39	1.71	1.85	1.69	[a] 0.46	0.14
July							
#7	1.60	1.35	1.63	1.74	1.65	[a] 0.39	0.14
#8	1.61	1.39	1.44	1.71	1.57	[a] 0.32	0.14
June							
#9	1.47	1.38	1.56	—	1.52	[a] 0.18	0.13
#10	—	1.39	1.57	—	1.68	[a] 0.29	0.12
May							
#11	1.69	1.50	1.41	1.54	1.56	[a] 0.28	0.14
#12	1.57	1.37	1.47	1.46	1.48	[a] 0.20	0.14
April							
#13	1.49	1.40	1.60	1.54	1.42	[a] 0.20	0.14
#14	1.62	1.39	1.51	—	1.43	[a] 0.23	0.13

[a] Observed range greater than allowable range.
[b] Dash indicates no analysis performed.

not as important as the other radionuclide determinations and are in most cases a by-product of the gamma spectroscopic analysis of milk, the analytical capability for such an analysis should be improved. Accordingly, in September 1963, a program similar to that carried out for Cs^{137} was in preparation. Hopefully, this study will uncover the cause of the disagreement among the laboratories for potassium analysis and enable corrective measures to be taken.

Analytical variations are associated with radioanalysis, as with other types of measurement. In view of the uncertainties in the biological parameters that control the use of the data, the analytical differences described in this report were acceptable for radiological health purposes.

Summary

The data tabulated in this report for April–October 1963 show that the agreement among several DRH laboratories for I^{131} and Ba^{140} analyses in milk was acceptable at the low levels observed during that period according to the pre-selected limits of analytical agreement.

Results for the first part of this period for Cs^{137} indicated that improvement was needed. After appropriate steps were taken, data for the latter part of the period indicated improvement in the analytical agreement for Cs^{137}. Results of the entire period for potassium were not acceptable, and steps to bring about better agreement are being taken.

The cross-check analysis has proved to be a useful tool in demonstrating analytical competence and in pointing out analytical discrepancies. Future reports will be made periodically by the Analytical Quality Control Service in *RHD* to update the findings of the cross-check program.

REFERENCES

(*1*) Rosenstein, M. and A. S. Goldin: The Analytical Quality Control Service of the Division of Radiological Health—Interlaboratory Study of Iodine–131 Surveillance Measurements in Milk, *Radiological Health Data, 5:* 128–131, Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. (March 1964).

(*2*) Hoel, P. G.: *Introduction to Mathematical Statistics*, Wiley, New York (1958), pp. 241–242.

(*3*) American Society for Quality Control: *Guide for Quality Control and Control Chart Method of Analyzing Data, ASQC Standards B1 and B2*, American Standards Association, New York (1958), $1.00. p. 21 (table 2).

Correction for June 1964 Issue

The table below was inadvertently omitted from the June 1964 issue article entitled "Strontium–90 in Plant Parts and Milling Fractions From a 1963 Illinois Wheat," by V. F. Pfeifer, A. J. Peplinski and J. E. Hubbard, on pages 283–4.

TABLE 3.—STRONTIUM–90 IN MILLING FRACTIONS FROM FIELD-COMBINED WHEAT

[Analyses on dry basis]

Fraction	Yield (Percent)	Protein (Percent)	Ash (Percent)	Calcium (Percent)	Sr^{90} (pc/kg)	Sr^{90} in fraction (Percent of total)
Wheat		11.5	1.96	0.039	[a] 87.1	100
Patent flour	59.9	10.3	0.46	0.014	18.3	10
First clear flour	12.8	11.3	0.90	0.025	49.5	6
Second clear flour	2.9	13.6	2.08	0.049	77.1	2
Shorts	3.7	[b] 17.1	4.90	0.104	321	11
Bran	20.7	[b] 17.4	6.69	0.118	369	71

[a] Sr^{90} in wheat, calculated from milling fractions = 107.8.
[b] Nitrogen content x 6.25.

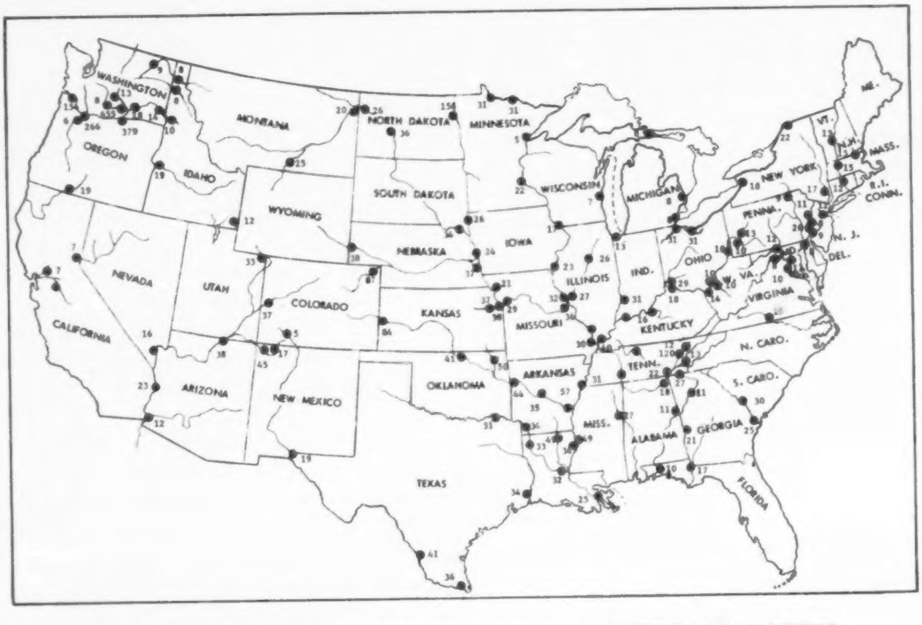
84

Section III—Water

RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, FEBRUARY 1964

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this System has expanded to 130 stations as of July 1, 1964. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U. S. river basins for physical, chemical, biological and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the System provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be subjected. Data assembled through the System are published in annual compilations (*1–7*).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MONTANA
NORTH DAKOTA
MINNESOTA
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FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATERS, FEBRUARY 1964

Sampling Procedures

The participating agencies collect one-liter "grab" samples each week and ship them to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids and strontium-90 determinations on total solids are performed as frequently as deemed necesary.

Presently, gross alpha and beta determinations are made on monthly composites of the weekly samples received from most stations. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are also conducted at newly established stations for the first year of operation.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

Analytical Methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*8*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counters.

Results

Table 1 presents February 1964 results of alpha and beta analyses of U. S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first station listed being closest to the head-waters. These data are preliminary. Replicate analyses of some samples as well as some analyses incomplete at the time of this report will be included in the System's Annual Compilation of Data (*7*). The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter. When all samples have zero pc/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5 the mean is reported as <1 pc/liter. The most recent quarterly strontium-90 results appear in this issue on page 391.

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the February 1964 average total beta activity in suspended-plus-dissolved solids in raw water collected at that station. Results for the years 1957-1962 have been summarized by Weaver *et al.* (*9*).

Discussion

The monthly dissolved beta activity averages exceeded 100 pc/liter only on the Columbia River, Clinch River and Red River, North. Of the six stations on the Columbia River, the four downstream from the Hanford Atomic Products Operations facility had averages of between 127 and 591 pc/liter. It can be observed that the concentration diminishes with distance downstream from the facility. Additional data on radioactivity in the Columbia River are presented and discussed in the articles on pages 386 and 395.

Dissolved alpha activity, which is associated with the dissolving of natural surface minerals by water reached a maximum observed monthly average of 40 pc/liter. Of all stations, five on different rivers had monthly average dissolved alpha activity greater than 10 pc/liter.

While there are no generally applicable standards for surface waters, the radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (*10*). The Public Health Service Drinking Water Standards state that in the absence of

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, FEBRUARY 1964

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River:						
Pittsbugh, Pa	6	7	13	0	0	0
Animas River:						
Cedar Hill, N. Mex	4	13	17	0	2	2
Apalachicola River:						
Chattahoochee, Fla	7	10	17	0	0	0
Arkansas River:						
Coolidge, Kansas	23	61	84	2	40	42
Ponca City, Okla	6	35	41	0	3	3
Fort Smith, Ark	11	33	44	1	4	5
Little Rock, Ark	14	21	35	<1	1	1
Pendleton Ferry, Ark	30	27	57	2	0	2
Bear River:						
Preston, Idaho	1	11	12	0	2	2
Big Horn River:						
Hardin, Mont	5	20	25	1	6	7
Big Sioux River:						
Sioux Falls, S. Dak	4	22	26	0	0	0
Chattahoochee River:						
Atlanta, Ga	5	6	11	0	0	0
Columbus, Ga	14	7	21	1	0	1
Lanett, Ala	5	6	11	1	0	1
Chena Slough:						
Fairbanks, Alaska	2	3	5	0	0	0
Clearwater River:						
Lewiston, Idaho	2	8	10	0	0	0
Clinch River:						
Clinton, Tenn	3	9	12	<1	0	<1
Kingston, Tenn	8	112	120	0	0	0
Colorado River:						
Loma, Colo	10	27	37	2	9	11
Page, Ariz	1	37	38	0	9	9
Boulder City, Nev	0	16	16	0	9	9
Parker Dam, Calif-Ariz	3	20	23	0	9	9
Yuma, Ariz	2	10	12	0	3	3
Columbia River:						
Northport, Wash	1	8	9	0	1	1
Wenatchee, Wash	0	13	13	0	1	1
Pasco, Wash	64	591	655	0	1	1
McNary Dam, Ore	24	[illegible]	279	0	1	1
Bonneville, Ore	32	234	266	0	1	1
Clatskanie, Ore	27	127	154	0	<1	<1
Connecticut River:						
Wilder, Vt	3	10	13	0	0	0
Northfield, Mass	6	9	15	0	0	0
Enfield Dam, Conn	2	10	12	0	0	0
Cuyahoga River:						
Cleveland, Ohio	2	29	31	0	0	0
Delaware River:						
Martins Creek, Pa	2	9	11	0	0	0
Trenton, N. J	3	5	8	1	0	1
Philadelphia, Pa	15	11	26	1	1	2
Escambia River:						
Century, Fla	4	6	10	0	0	0
Great Lakes:						
Duluth, Minn	1	4	5	0	0	0
Sault Ste. Marie, Mich	2	6	8	0	0	0
Milwaukee, Wisc	1	6	7	0	0	0
Gary, Ind	5	8	13	0	0	0
Port Huron, Mich	1	7	8	0	0	0
Detroit, Mich	0	8	8	0	0	0
Buffalo, New York	2	16	18	0	0	0
Green River:						
Dutch John, Utah	0	33	33	0	2	2
Hudson River:						
Poughkeepsie, N. Y	5	12	17	0	0	0
Illinois River:						
Peoria, Ill	10	16	26	2	0	2
Grafton, Ill	8	24	32	0	3	3
Kanawha River: Winfield Dam, W. Va	5	5	10	0	0	0
Kansas River:						
De Soto, Kansas	8	29	36	0	4	4
Klamath River:						
Keno, Oreg	5	14	19	0	0	0
Little Miami River:						
Cincinnati, Ohio	7	22	29	0	1	1
Maumee River:						
Toledo, Ohio	7	24	31	<1	0	<1
Merrimack River:						
Lowell, Mass	2	13	15	0	0	0
Mississippi River:						
St. Paul, Minn	2	20	22	0	1	1
Dubuque, Iowa	1	16	17	0	0	0
Burlington, Iowa	4	19	23	0	1	1
E. St. Louis, Ill	7	20	27	0	2	2
Cape Girardeau, Mo	11	19	30	0	1	1
W. Memphis, Ark	18	13	31	2	1	3
Vicksburg, Miss	30	19	49	3	0	3
Delta, La	19	15	34	5	2	7
New Orleans, La	11	14	25	1	1	2
Missouri River:						
Williston, N. Dak	8	18	26	1	4	5
Bismarck, N. Dak	6	30	36	0	3	3
Yankton, S. Dak	10	24	34	1	8	9
Omaha, Nebr	3	21	24	1	4	5
St. Joseph, Mo	1	20	21	0	5	5
Kansas City, Kans	14	24	38	1	11	12
Missouri City, Mo	8	21	29	0	4	4
St. Louis, Mo	12	24	36	[illegible]	1	1
Monongahela River:						
Pittsburgh, Pa	3	7	10	0	0	0
North Platte River:						
Henry, Nebr	5	33	38	0	32	32
Ohio River:						
Toronto, Ohio	2	8	10	0	0	0
Addison, Ohio	2	8	10	0	0	0
Huntington, W. Va	7	7	14	0	0	0
Cincinnati, Ohio	9	9	18	1	0	1
Louisville, Ky	9	7	16	1	0	1
Evansville, Ind	8	10	18	2	0	2
Cairo, Ill	29	11	40	8	1	9
Ouachita River:						
Bastrop, La	30	19	49	1	3	4
Pend Oreille River:						
Albeni Falls Dam, Idaho	1	7	8	0	0	0
Platte River:						
Plattsmouth, Nebr	16	21	37	1	8	9
Potomac River:						
Williamsport, Md	6	6	12	0	0	0
Great Falls, Md	9	8	17	0	0	0
Washington, D.C	3	7	10	<1	0	<1
Rainy River:						
Baudette, Minn	3	28	31	1	0	1
International Falls, Minn	1	30	31	0	0	0
Raritan River:						
Perth Amboy, N. J. (5 ft. Below Surface)	2	10	12	0	1	1
Perth Amboy, N. J. (5 ft. Above Bottom)	4	9	13	0	3	3
Red River, North:						
Grand Forks, N. Dak	17	139	156	1	3	4
Red River, South:						
Denison, Tex	3	48	51	0	2	2
Index, Ark	3	31	34	0	4	4
Bossier City, La	11	22	33	1	0	1
Alexandria, La	11	21	32	2	2	4
Rio Grande River:						
Alamosa, Colo	0	5	5	1	0	1
El Paso, Tex	1	18	19	0	4	4
Laredo, Tex	17	24	41	0	4	4
Brownsville, Tex	5	31	36	0	4	4
Roanoke River:						
John H. Kerr Res/Dam, Va	6	9	15	0	0	0
Sabine River:						
Ruliff, Tex	12	22	34	0	0	0
Sacramento River:						
Courtland, Calif	1	6	7	0	0	0
San Joaquin River:						
Vernalis, Calif	3	19	22	0	5	5
San Juan River:						
Shiprock, N. Mex	11	34	45	2	15	17
Savannah River:						
North Augusta, S. C	11	19	30	0	0	0
Port Wentworth, Ga	7	18	25	<1	0	<1
Schuylkill River:						
Philadelphia, Pa	1	8	9	0	0	0
Shenandoah River:						
Berryville, Va	2	6	8	0	0	0
Ship Creek:						
Anchorage, Alaska	1	1	2	0	0	0
Snake River:						
Ice Harbor Dam, Wash	2	12	14	0	2	2
Wawawai, Wash	6	12	[illegible]	0	3	3
Payette, Idaho	3	16	19	0	4	4
South Platte River:						
Julesburg, Colo	30	57	87	5	40	45
Spokane River:						
Post Falls Dam, Idaho	2	6	8	0	0	0
Susquehanna River:						
Sayre, Pa	1	8	9	0	0	0
Conowingo, Md	1	7	8	0	0	0
Tennessee River:						
Lenoir City, Tenn	5	8	13	0	0	0
Chattanooga, Tenn	7	20	27	<1	<1	<1
Bridgeport, Ala	3	15	18	0	0	0
Pickwick Landing, Tenn	6	16	22	0	0	0
Tombigbee River:						
Columbus, Miss	10	17	27	1	0	1
Truckee River:						
Farad, Calif	1	6	7	0	0	0
Verdigris River:						
Nowata, Okla	10	40	50	0	1	1
Wabash River:						
New Harmony, Ind	9	22	31	0	<1	<1
Willamette River:						
Portland, Oreg	3	3	6	0	0	0
Yakima River:						
Richland, Wash	1	7	8	0	1	1
Yellowstone River:						
Sidney, Mont	2	18	20	1	5	6
Maximum	64	591	655	8	40	45
Minimum	0	1	2	0	0	0

Note: These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the network's Annual Compilation of Data (7).

strontium-90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentration does not exceed 1000 pc/liter (*11*).

REFERENCES

(*1*) Division of Water Supply and Pollution Control, Public Health Service: *National Water Quality Network Annual Compilation of Data, PHS Publication No. 663, 1958 Edition*, Superintendent of Documents, U. S. Government Printing Office, Washington D. C. 20402. Price $1.50.

(*2*) *Ibid.*, 1959 Edition. Price $1.75.

(*3*) *Ibid.*, 1960 Edition.[2]

(*4*) *Ibid.*, 1961 Edition.[2]

(*5*) *Ibid.*, 1962 Edition.[2]

(*6*) *Ibid.*, 1963 Edition (in press).

(*7*) *Ibid.*, 1964 Edition (to be published).

(*8*) American Public Health Association, American Water Works Association and Water Pollution Control Federation: *Standard Methods for the Examination of Water and Wastewater*, 11th Edition, New York (1960).

(*9*) Weaver, L., A. W. Hoadley, and S. Baker: Radioactivity in Surface Waters of the United States, 1957–1962, *Radiological Health Data, 4:* 306–16, (June 1963).

(*10*) Straub, C. P.: Significance of Radioactivity Data, *Journal of the American Water Works Association 53:* 704 (June 1961).

(*11*) Public Health Service: *Drinking Water Standards, Revised 1962, Public Health Service Publication No. 956*, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (March 1963), price 30 cents.

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[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pc/liter and 10 pc/liter for unidentified alpha emitters and strontium-90, respectively.

[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U. S. Department of Health, Education and Welfare, Washington, D. C. 20201.

RADIOACTIVITY IN WASHINGTON SURFACE WATER[1] JULY 1962—JUNE 1963

Robert R. Mooney and Peter W. Hildebrandt[2]

Radioanalysis of surface water samples collected throughout the State of Washington is one of the major functions of the Washington State Department of Health radiation surveillance program. Surface water samples are usually collected on a quarterly schedule from 71 stations located on 65 rivers throughout the State. These samples are collected by the Washington Pollution Control Commission, and are sent to the Department of Health for radiological analyses. A few other locations are sampled less frequently, and selected stations on the Columbia River[3] are sampled weekly by local health department sanitarians.

Sampling and Analytical Procedures

All surface water samples are collected as grab samples in 2-liter plastic bottles. Two milliliters of concentrated nitric acid are added to the sample before shipment to the laboratory to prevent loss of activity to the container.

Surface water samples are placed in stainless steel Marinelli beakers for the gamma scans. Distilled water is added when necessary to obtain 2-liter volumes for standardizing counting geometry. These samples are gamma scanned for 100 minutes approximately two weeks after collection. This two-week period permits the decay of short-lived isotopes (Na^{24}, As^{76}, Np^{239}) in Columbia River water samples. The matrix method, utilizing a 4 x 4 matrix, permits the quantative determination of Cr^{51}, Ru^{106}, Zr^{95}, and Zn^{65}. Results are extrapolated to the date of collection.

The counting equipment consists of a 3 x 3-inch gamma scintillation crystal and 512–channel analyzer. A one-minute count each day of a cesium–137 standard is performed as an efficiency check and a ten-minute count each week is done to check the resolution. An 800–minute count each week is taken to check the background. Table 1 gives the gamma efficiencies and detectability limits for this system.

After the gamma scan, the water samples receive further preparation and are beta counted for suspended and soluble radioactivity. The separation of dissolved and suspended activity is accomplished by filtering the sample (What-

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[1] Summarized from *Environmental Radiation Surveillance in Washington State*, (*1*).

[2] Mr. Mooney is Engineer and Mr. Hildebrandt is Technical Director, Air and Radiation Control Section, State Department of Health, Seattle, Washington.

[3] For other data concerning the Columbia River see page 395 of this issue.

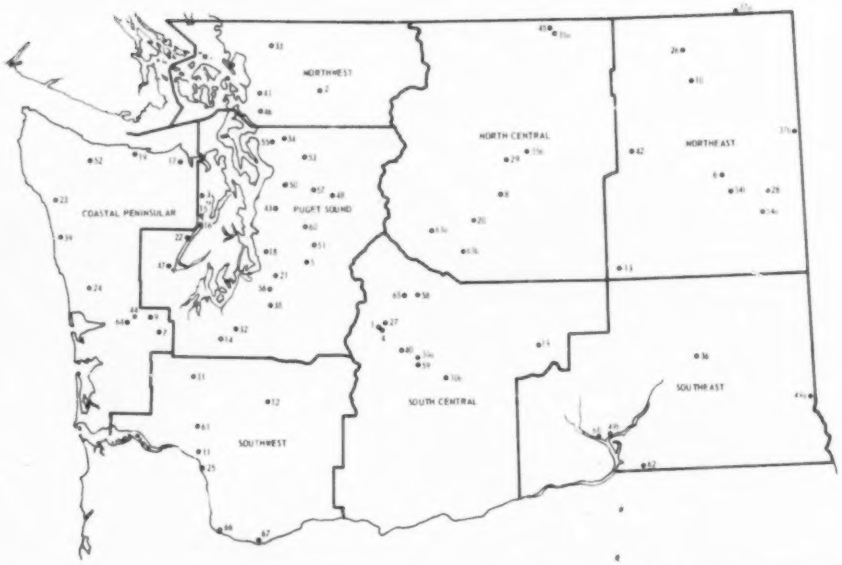

Figure 1.—WASHINGTON SURFACE WATER SAMPLING LOCATIONS WITH CODE NUMBERS

man #42 filter paper). The filtrate, evaporated to near dryness, is quantitatively transferred to a tared planchet and dried for gross beta counting. The filter paper containing the suspended activity is ashed in a muffle furnace at 600°C and plancheted for gross beta counting. After obtaining the net beta counting rate, corrections for self absorption are made and the results converted to concentrations in water. Beta results are not extrapolated to date of collection.

Table 1.—GAMMA EFFICIENCIES AND DETECTABILITY LIMITS FOR THE WASHINGTON STATE ANALYSES

Radionuclide	Energy band (Mev)	Efficiency (%)	Average background (pc)	Detectability limits (pc)
Cr^{51}	0.30–0.36	0.45	2,800	220
Ru^{106}	0.44–0.56	0.94	1,360	100
Zr^{95}	0.73–0.79	6.00	60	10
Zn^{65}	1.05–1.17	0.94	370	50

Through May 1963, beta counting was performed in an internal proportional gas-flow counter with an average background of 12.5 counts per minute. Since that time, beta counting has been done with a low background beta system including a 2-inch detector and automatic sample changer. This system has an average background of 0.5 counts per minute. One-hour background counts are performed daily. Calibration of the instrument is done with a Sr^{90}–Y^{90} standard.

Results

Table 2 presents the monthly average results for the two Columbia River stations which are sampled routinely. In averaging, a less-than value is assumed to be equal to the full value. Samples from this river are generally gamma scanned for four radionuclides (Cr^{51}, Ru^{106}, Zr^{95}, Zn^{65}), following which the suspended and dissolved solids are each analyzed for total beta activity.

Samples from other rivers are analyzed for total beta activity of the dissolved and of the suspended fractions. Table 3 summarizes all analyses of the 65 locations from July 1962 through June 1963. The first column in this table gives code numbers and the abbreviations denoting geographical sections (in figure 1). Each river is assigned a number and if more than one station is located on that river, lower case letters are used to designate these stations. For example, code number 21 refers to the Green River sampling station in the area desig-

TABLE 2.—MONTHLY AVERAGE RADIOACTIVITY IN COLUMBIA RIVER WATER, OCTOBER 1962-JUNE 1963

[Concentrations in pc/liter]

Sampling and type of sample	Oct. 62	Nov. 62	Dec. 62	Jan. 63	Feb. 63	Mar. 63	Apr. 63	May 63	June 63
Pasco (Code No. 68)									
Beta									
Suspended	[a] —	—	—	—	48	79	207	44	33
Dissolved	—	—	—	—	150	389	230	83	32
Total	—	—	—	—	198	468	437	127	65
Gamma									
Chromium-51	—	—	—	—	4,900	10,060	6,720	3,200	2,430
Ruthenium-106	—	—	—	—	250	120	76	<50	<50
Zirconium-95	—	—	—	—	6	15	6	<5	<5
Zinc-65	—	—	—	—	249	479	404	249	133
Vancouver (Code No. 66)									
Beta									
Suspended	18	—	48	22	30	27	29	29	18
Dissolved	61	—	70	75	61	83	120	63	20
Total	79	—	118	97	91	110	149	92	38
Gamma									
Chromium-51	3380	—	2460	2200	1840	2690	3000	2030	1500
Ruthenium-106	<50	—	<50	<50	75	55	<50	<50	<50
Zirconium-95	<5	—	<5	5	10	5	5	<5	<5
Zinc-65	35	—	50	73	71	77	118	73	75
Washougal (Code No. 67)									
Beta									
Suspended	—	—	49	27	42	27	40	27	21
Dissolved	—	—	53	75	83	94	140	53	24
Total	—	—	102	102	125	121	180	80	45
Gamma									
Chromium-51	—	—	2560	2360	2130	2950	3330	2070	1580
Ruthenium-106	—	—	<50	<50	69	<50	<50	<50	<50
Zirconium-95	—	—	<5	<5	14	<5	10	<5	<5
Zinc-65	—	—	52	81	82	95	98	83	83

[a] Dash indicates no samples taken.

nated "PS", i.e. Puget Sound. The third column gives the total number of samples analyzed. Some samples (four) had analyses performed only on either suspended or dissolved solids. Twenty samples had analyses performed on the total solids only. Less-than values are assigned the full value in averaging.

The network summary gives the maximum and minimum value for the 274 samples analyzed, while the network average is obtained by averaging all the station average values.

Discussion

Of the 274 river water samples analyzed during July 1962 through June 1963 (excluding the Columbia River), the total beta activity ranged from 3 to 164 pc/liter with an average of 24.0 pc/liter. The activity of soluble fraction was somewhat lower, ranging from 2 to 101 pc/liter and averaging 16.6 pc/liter.

The following observations apply to the period December 1962 through July 1963, when continued surveillance was in progress: monthly average total beta activity for the Columbia River stations ranged from 38 to 180 pc/liter. The gamma emitters Ru^{106} and Zr^{95} were found in Columbia River water with monthly average concentrations ranging from <50 to 75 pc/liter for Ru^{106} and <5 to 14 pc/liter for Zr^{95}. The values for Ru^{106} are probably representative of a combination of Ru^{103} and Ru^{106}. The radionuclides Ru^{106} and Zr^{95} were found in other river basins as well as in the Columbia River. Two other gamma emitting radionuclides, Cr^{51} and Zn^{65}, were found in detectable quantities only in Columbia River water. Monthly averages for Cr^{51} ranged from 1499 to 3329 pc/liter and for Zn^{65} the range was 50 to 118 pc/liter.

Although any standards for gross beta activity must be very carefully applied, the standard for drinking water is 1000 pc/liter of beta activity in the absence of strontium-90 and alpha emitters (*2*). The standards for water from all dietary sources for the general population at large (*3*) are:

Cr^{51}, 670,000 pc/liter; Ru^{106}, 3,300 pc/liter; Zr^{95}, 20,000 pc/liter; Zn^{65}, 10,000 pc/liter.

REFERENCES

(*1*) Mooney, R. R. and P. W. Hildebrandt: *Environmental Radiation Surveillance in Washington State*, Washington State Department of Health, Olympia, Washington, Limited Distribution (August 1963).

TABLE 3.—BETA ACTIVITY IN WASHINGTON SURFACE WATER, JULY 1962-JUNE 1963

Code number and area	Sampling location (river)	Number of samples	Suspended			Dissolved			Total		
			Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum
1 SC	American	3	11	<1	30	13	3	33	24	4	63
2 NW	Baker	3	7	2	11	25	20	31	32	22	42
3 PS	Big Quiliene	3	1	<1	1	4	2	8	5	3	9
4 SC	Bumping	3	2	<1	2	10	7	15	12	9	16
5 PS	Cedar	12	9	<1	36	24	3	57	31	3	93
6 NE	Chamokane	2	7	6	7	11	4	17	18	10	24
7 CP	Chehalis	6	4	<1	10	11	4	18	16	5	28
8 NC	Chelan	4	3	<1	5	9	4	12	12	5	18
9 CP	Cloquallam	4	2	<1	3	16	4	26	15	3	29
10 NE	Colville	6	6	2	13	12	5	2	18	9	39
11 SW	Coweman	4	24	1	47	17	12	24	32	3	59
12 SW	Cowlitz	3	3	1	6	12	5	19	15	6	25
13 SC	Crab	4	5	3	8	17	8	23	21	13	28
14 PS	Deschutes	4	3	<1	6	8	4	16	11	5	22
15 PS	Dosewallips	2	3	2	3	8	7	8	10	10	10
16 PS	Duckabush	3	2	<1	3	6	4	7	7	5	8
17 CP	Dungeness	3	1	<1	2	6	4	8	7	5	10
18 PS	Duwamish	4	10	<1	20	18	4	32	28	5	52
19 CP	Elwha	3	1	<1	2	6	5	7	7	6	9
20 NC	Entiat	4	3	<1	8	9	2	17	12	3	25
21 PS	Green	5	5	<1	12	14	2	23	17	3	27
22 PS	Hamma Hamma	3	1	<1	<1	5	4	6	6	5	7
23 CP	Hoh	3	3	<1	4	9	3	13	12	4	17
24 CP	Humptulips	4	3	<1	9	11	3	20	14	4	28
25 SW	Kalama	4	11	<1	21	16	4	24	21	3	40
26 NE	Kettle	3	15	3	27	11	11	11	12	10	14
27 SC	Little Naches	3	9	<1	23	11	4	25	20	6	48
28 NE	Little Spokane	4	9	<1	16	17	10	28	19	3	44
29 NC	Methow	4	3	<1	6	9	6	14	12	7	20
30a SC	Naches	3	9	6	11	8	3	11	17	13	22
30b SC	Naches	4	4	<1	8	8	4	10	12	5	18
31 SW	Newaukum	3	5	<1	9	11	8	14	12	3	23
32 PS	Nisqually	4	6	1	11	15	7	26	21	8	37
33 NW	Nooksak	4	27	6	64	32	8	49	59	14	113
34 PS	N. Stillaguamish	4	19	9	26	43	35	47	48	6	73
35a NC	Okanogan	4	5	<1	13	17	9	30	22	10	43
35b NC	Okanogan	4	7	<1	13	16	8	30	23	9	43
36 SE	Palouse	3	13	4	31	30	20	50	22	24	81
37 a NE	Pend Oreille	3	4	2	7	31	16	38	35	20	45
37 b NE	Pend Oreille	4	15	<1	33	19	15	22	27	16	55
38 PS	Puyallup	4	4	2	7	17	14	21	21	17	24
39 CP	Queets	3	3	<1	7	7	3	14	10	4	21
40 SC	Rattlesnake	3	9	<1	26	9	5	15	18	6	41
41 NW	Samish	4	11	5	16	33	18	46	34	3	62
42 NE	Sanpoil	3	3	1	4	16	8	30	44	9	33
43 PS	Sammamish	4	14	<1	46	15	7	19	29	8	64
44 CP	Satsop	4	5	<1	16	13	2	45	18	3	61
45 NC	Similkameen	4	3	<1	6	13	10	14	16	14	19
46 NW	Skagit	4	9	2	12	25	10	34	34	12	46
47 PS	Skokomish	3	4	<1	9	7	3	12	11	4	21
48 PS	Skykomish	3	10	6	18	18	27	85	58	33	103
49a SE	Snake	4	10	3	20	20	11	30	28	14	48
49b SE	Snake	4	10	1	16	20	14	30	30	15	38
50 PS	Snakomish	4	9	<1	16	20	3	29	29	4	43
51 PS	Snoqualimie	4	16	<1	40	29	4	48	45	5	88
52 CP	Soleduck	2	1	<1	1	6	4	7	7	5	8
53 PS	S. Stillaguamish	4	12	<1	20	35	7	55	47	8	73
54a NE	Spokane	4	7	1	13	19	19	20	21	21	33
54b NE	Spokane	4	5	1	13	22	10	36	22	11	38
55 PS	Stillaguamish	4	16	<1	27	36	5	58	52	6	79
56 PS	Stuck	4	3	<1	5	21	7	43	24	9	47
57 PS	Sultan	4	14	<1	30	39	3	94	53	4	124
58 SC	Teanaway	4	8	<1	21	8	3	14	16	4	35
59 SC	Tieton	2	8	7	9	11	10	11	19	17	20
60 PS	Tolt	4	23	<1	63	38	2	101	61	3	164
61 SW	Toutle	4	7	<1	10	17	7	27	19	4	36
62 SE	Walla Walla	4	6	<1	19	13	7	22	19	8	32
63a NC	Wenatchee	4	2	<1	3	13	4	26	15	5	29
63b NC	Wenatchee	3	8	<1	10	15	11	18	23	12	26
64 CP	Wynoochee	4	15	<1	56	4	2	6	19	3	58
65 SC	Yakima	11	7	<1	23	13	6	31	20	7	41
Network summary		271	7.8	<1	64	16.6	2	101	23.0	3	164

(2) Public Health Service: *Public Health Service Drinking Water Standards, PHS No. 956* (Reprinted August 1963), Superintendent of Documents, Washington, D. C. 20402, price 30 cents.

(3) International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

91

TRENDS OF STRONTIUM-90 LEVELS IN SURFACE WATERS OF THE UNITED STATES, 1959—1963

Earl P. Floyd and Leo Weaver[1]

Radioactivity levels in surface waters of the major river basins have been monitored by the Public Health Service Water Pollution Surveillance System since 1957. However, strontium-90 determinations did not begin until 1959.

Initially, strontium-90 analyses of total solids were made quarterly on three-month composites of aliquots from weekly samples. Beginning in November 1962, the frequency of analysis was reduced to two quarterly samples per year at each sampling point except those stations immediately below nuclear installations, where quarterly analyses were continued.

Through September 1961, the method used for determining strontium-90 was that described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*1*). Tributyl phosphate was used to extract ingrown yttrium-90 from the purified, coprecipitated strontium-90. Beginning in October 1961, a modification of a procedure described by Harley has been used (*2*). The yttrium-90 together with an yttrium carrier is precipitated at pH 8.5; the precipitate is washed, redissolved, and reprecipitated as yttrium oxalate and the latter is washed and counted in a low-background anticoincidence, end-window proportional counter.

Results

Table 1 presents the results of quarterly analyses of strontium-90 concentrations in U. S. surface waters from October 1962 through December 1963. The stations are arranged in the table according to their relative location on the river, the first station listed being closest to the head-waters.

In order to summarize all the quarterly strontium-90 in surface water results, figure 1 shows the trend of the strontium-90 averages observed in the Surveillance System from 1959 through 1963.

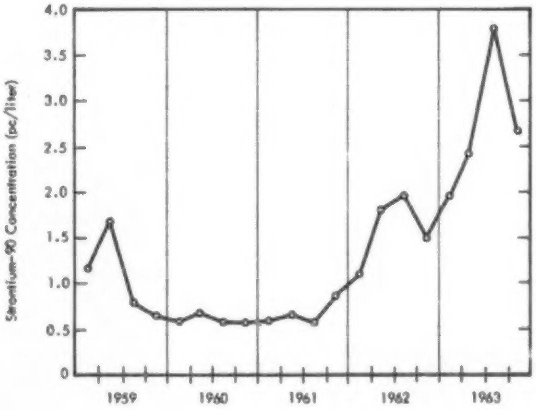

FIGURE 1.—NETWORK AVERAGE STRONTIUM-90 CONCENTRATIONS (QUARTERLY MEANS) IN SURFACE WATERS

Discussion

Completion of analyses on quarterly composites of weekly samples for the last half of 1963 revealed a sharp increase during July–September followed by a decline during October–December of the strontium-90 levels in surface waters of the North Central area of the conterminous States (see figure 2). This trend, as well as the relationship between the National average and the North Central average strontium-90 concentration, is shown in table 2. It is observed that the North Central area mean is ⅓ to ½ greater than the national mean during the last half of 1963. For comparison, the results for July–September 1961 are included since they represent essentially background levels. Chronological trends are similar; the highest values recorded during July–September 1963 are in the North Central area. This may also be seen in figure 2, which shows the maximum, minimum, and average strontium-90 concentrations in surface waters in different river basins for the period July–September 1963.

The highest quarterly strontium-90 value for any station in the system recorded to date is 12.6 pc/liter; this occurred in the Clinch River.

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[1] Mr. Floyd is Radiochemist and Mr. Weaver is Chief, Water Quality Section, Basic Data Branch, Division of Water Supply & Pollution Control, Public Health Service, 1014 Broadway, Cincinnati, Ohio 45226.

TABLE 1.—QUARTERLY AVERAGE STRONTIUM-90 CONCENTRATIONS IN SURFACE WATERS, OCTOBER 1962-DECEMBER 1963

[Concentrations in pc/liter]

Station	Oct.–Dec. 1962	Jan.–Mar. 1963	Apr.–June 1963	July–Sept. 1963	Oct.–Dec. 1963
Allegheny River:					
Pittsburgh, Pa	1.8	[a]—	1.8	—	2.8
Animas River:					
Cedar Hill, N. Mex	0.9	—	—	1.8	—
Apalachicola River:					
Chattahoochee, Fla	0.9	—	—	2.9	—
Arkansas River:					
Coolidge, Kans	1.0	1.0	—	6.6	—
Ponca City, Okla	2.2	—	5.9	6.5	4.4
Fort Smith, Ark	—	—	—	6.7	—
Little Rock, Ark	—	—	—	4.8	4.4
Pendleton Ferry, Ark	—	—	5.5	—	4.3
Bear River:					
Preston, Idaho	0.9	—	—	3.7	—
Big Horn River:					
Hardin, Mont	1.3	—	5.8	—	2.3
Big Sioux River:					
Sioux Falls, S. Dak	2.5	—	—	9.5	5.0
Chattahoochee River:					
Atlanta, Ga	1.0	3.6	1.6	—	1.7
Columbus, Ga	1.1	—	1.5	—	1.7
Lanett, Ala	0.8	—	—	2.0	—
Chena Slough:					
Fairbanks, Alaska	0.3	—	0.7	—	0.2
Clearwater River:					
Lewiston, Idaho	0.4	—	—	1.2	—
Clinch River:					
Clinton, Tenn	1.0	—	—	1.4	—
Kingston, Tenn	—	6.3	5.6	9.4	6.5
Colorado River:					
Loma, Colo	0.5	—	2.5	—	1.4
Page, Ariz	6.9	1.5	—	4.2	—
Boulder City, Nev	1.5	—	1.8	—	1.5
Parker Dam, Calif-Ariz	1.3	—	—	1.0	—
Yuma, Ariz	0.9	—	0.9	—	1.1
Columbia River:					
Northport, Wash	0.9	—	—	3.4	—
Wenatchee, Wash	1.6	—	1.1	—	2.8
Pasco, Wash	1.5	2.3	2.4	2.7	3.4
McNary Dam, Ore	1.0	1.4	1.1	2.6	2.5
Bonneville, Ore	1.2	—	—	1.2	—
Clatskanie, Ore	0.9	—	1.3	2.5	1.6
Connecticut River:					
Wilder, Vt	0.9	—	—	2.6	—
Northfield, Mass	1.0	—	1.4	3.1	1.8
Enfield Dam, Conn	1.0	—	—	2.5	—
Cumberland River:					
Clarksville, Tenn	—	—	—	2.0	—
Cuyahoga River:					
Cleveland, Ohio	—	1.4	—	5.3	—
Delaware River:					
Martins Creek, Pa	1.2	—	1.7	—	1.6
Trenton, N. J	0.9	—	—	3.1	—
Philadelphia, Pa	2.4	—	1.1	—	2.1
Escambia River:					
Century, Fla	—	—	1.4	—	1.2
Great Lakes:					
Duluth, Minn	0.7	—	0.4	—	0.7
Sault Ste. Marie, Mich	0.8	—	—	1.5	—
Milwaukee, Wisc	0.8	—	0.8	—	0.8
Gary, Ind	0.7	—	—	1.6	—
Port Huron, Mich	0.8	—	1.3	—	1.2
Detroit, Mich	1.1	—	—	2.4	—
Buffalo, N. Y	1.7	—	2.2	—	2.5
Green River:					
Dutch John, Utah	1.2	—	—	2.7	—
Hudson River:					
Poughkeepsie, N. Y	3.0	—	3.8	—	5.0
Illinois River:					
Peoria, Ill	1.7	—	3.5	—	2.3
Grafton, Ill	1.8	—	—	4.4	—
Kanawha River:					
Winfield Dam, W. Va	1.1	—	—	2.9	—
Kansas River:					
De Soto, Kans	—	—	4.9	7.4	5.2
Klamath River:					
Keno, Ore	0.9	—	1.4	—	1.8
Little Miami River:					
Cincinnati, Ohio	1.6	—	—	5.3	1.4
Maumee River:					
Toledo, Ohio	—	3.6	4.9	—	2.7
Merrimack River:					
Lowell, Mass	0.9	—	—	1.6	—
Mississippi River:					
St. Paul, Minn	3.4	—	—	7.2	4.3
Dubuque, Iowa	2.6	—	4.2	—	3.7
Burlington, Iowa	2.1	—	—	7.3	4.3
E. St. Louis, Ill	1.8	—	4.0	—	3.8
Cape Girardeau, Mo	2.7	—	—	5.3	—
W. Memphis, Ark	2.0	—	3.6	—	3.6
Vicksburg, Miss	2.0	—	—	4.2	—
Delta, La	2.1	—	3.3	—	3.4
New Orleans, La	1.9	—	—	4.5	—
Missouri River:					
Williston, N. Dak	1.5	—	2.5	—	2.8
Bismarck, N. Dak	1.7	—	—	3.5	—
Yankton, S. Dak	2.3	—	3.3	—	3.3
Omaha, Nebr	2.5	—	—	4.5	—
St. Joseph, Mo	1.9	—	6.2	—	3.4
Kansas City, Kans	3.4	—	—	5.0	—
Missouri City, Mo	2.6	—	4.1	—	4.1
St. Louis, Mo	2.7	—	—	6.2	—
Monongahela River:					
Pittsburgh, Pa	1.5	—	2.7	3.3	3.3
North Platte River:					
Henry, Nebr	0.6	1.1	2.5	—	0.7
Ohio River:					
Addison, Ohio	2.1	—	—	4.0	—
Huntington, W. Va	1.6	—	1.9	—	3.0
Cincinnati, Ohio	1.6	—	—	3.7	—
Louisville, Ky	1.4	—	2.3	3.6	4.0
Evansville, Ind	1.6	—	—	4.2	—
Cairo, Ill	1.7	—	2.9	—	2.8
Toronto, Ohio	—	—	—	4.9	2.8
Ouachita River:					
Bastrop, La	1.6	—	—	4.5	
Pend Oreille River:					
Albeni Falls Dam, Idaho	0.7	—	0.9	—	1.3
Platte River:					
Plattsmouth, Nebr	2.3	—	—	5.2	—
Potomac River:					
Williamsport, Md	1.6	—	1.4	—	1.7
Great Falls, Md	1.0	—	—	2.5	—
Washington, D. C	—	—	—	3.4	—
Rainy River:					
Baudette, Minn	2.2	—	2.5	4.7	4.1
International Falls, Minn	1.8	—	2.9	4.3	3.8
Raritan River:					
Perth Amboy, N. J. (5-ft. Below Surface)	—	—	—	—	—
Perth Amboy, N. J. (5-ft. Above Bottom)	—	—	—	—	—
Red River, North:					
Grand Forks, N. Dak	—	—	—	11.3	7.1
Red River, South:					
Denison, Tex	5.0	—	—	5.6	—
Index, Ark	3.3	—	5.3	4.9	4.3
Bossier City, La	2.0	—	—	5.0	—
Alexandria, La	3.9	—	4.0	—	4.1
Rio Grande River:					
Alamosa, Colo	0.5	—	1.1	—	0.8
El Paso, Tex	0.7	—	—	1.9	—
Laredo, Tex	1.8	—	3.7	—	2.4
Brownsville, Tex	1.3	—	—	2.3	—
Roanoke River:					
John H. Kerr Resr/Dam, Va	1.1	—	1.3	—	2.6
Sabine River:					
Ruliff, Tex	1.4	—	—	3.2	—
Sacramento River:					
Courtland, Calif	0.9	—	—	1.4	1.0
St. Lawrence River:					
Massena, N. Y	1.2	—	—	2.3	—
San Joaquin River:					
Vernalis, Calif	1.0	—	1.3	—	1.5
San Juan River:					
Shiprock, N. Mex	1.7	1.5	1.9	—	2.1
Savannah River					
North Augusta, So. Car	0.6	—	—	2.1	—
Port Wentworth, Ga	1.5	2.4	2.2	3.2	2.4
Schuylkill River:					
Philadelphia, Pa	1.3	—	—	3.7	—
Shenandoah River:					
Berryville, Va	0.8	—	1.2	—	1.0
Ship Creek:					
Anchorage, Alaska	0.3	—	—	0.9	—
Snake River:					
Ice Harbor Dam, Wash	1.6	—	—	1.3	—
Wawawai, Wash	0.7	—	0.9	—	0.7
Payette, Idaho	0.8	—	1.5	—	0.8
South Platte River:					
Julesburg, Colo	0.8	0.8	1.7		1.8
Spokane River:					
Post Falls, Idaho	0.8	—	—	1.2	—
Susquehanna River:					
Sayre, Pa	1.0	—	—	2.3	3.0
Conowingo, Md	1.2	—	1.6	—	
Tennessee River:					
Lenoir City, Tenn	1.0	—	1.5	—	2.1
Chattanooga, Tenn	1.4	2.6	1.7	3.3	2.2
Bridgeport, Ala	1.0	—	1.6	—	2.2
Pickwick Landing, Tenn	1.4	—	—	2.5	—
Tombigbee River:					
Columbus, Miss	0.6	—	—	3.6	—
Truckee River:					
Farad, Calif	0.9	—	1.0	—	1.0
Verdigris River:					
Nowata, Okla	2.5	—	4.2	—	6.0
Wabash River:					
New Harmony, Ind	1.4	—	3.1	—	2.5
Willamette River:					
Portland, Ore	0.6	—	0.7	—	0.5
Yakima River:					
Richland, Wash	0.4	—	—	1.0	—
Yellowstone River:					
Sindey, Mont	2.0	—	—	5.0	—
Maximum	6.9	6.3	6.2	11.3	7.1
Minimum	0.3	0.8	0.4	0.9	0.2

[a] Dash indicates no sample collected.

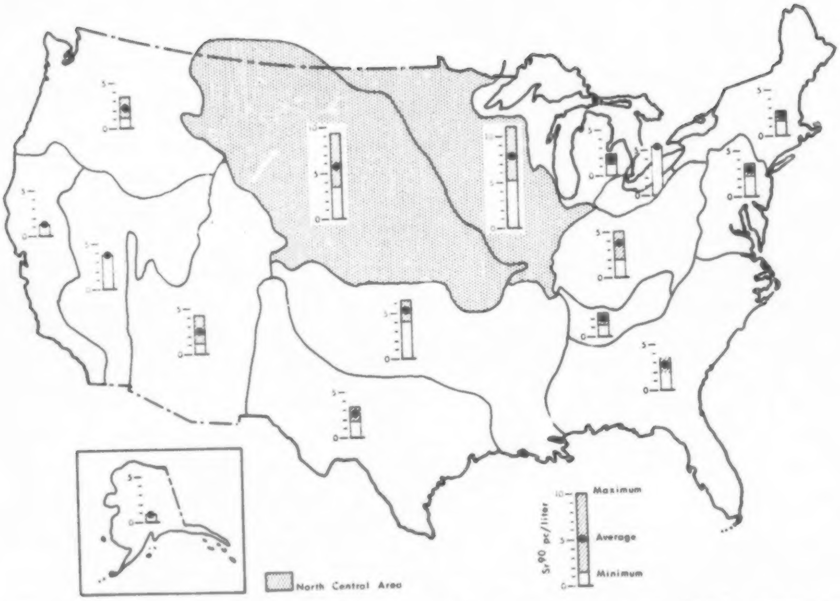

FIGURE 2.—DELINEATION OF THE NORTH CENTRAL AREA AND AVERAGE MAXIMUM AND MINIMUM STRONTIUM-90 CONCENTRATIONS IN SURFACE WATERS OF THE MAJOR RIVER BASINS, JULY–SEPTEMBER 1963

TABLE 2.—QUARTERLY AVERAGE STRONTIUM-90 LEVELS IN SURFACE WATER OF THE UNITED STATES

Period	National		North Central Area of U.S.	
	Number of samples	Strontium-90 (pc/liter)	Number of samples	Strontium-90 (pc/liter)
1961				
July-September	39	0.6	7	0.9
1963				
July-September	67	3.8	17	6.0
October-December	73	2.7	17	3.9

The second largest value, 11.3 pc/liter, was recorded for the sampling stations on the Red River of the North at Grand Forks, N. Dakota, during July–September 1963. The previously reported highest value (excluding the Clinch River value) of strontium-90 in the Surveillance System data was a 6.4 pc/liter concentration for the April–June 1962 composite from the Big Horn River at Hardin, Montana. Eight of the July–September 1963 composite sample determinations indicated results higher than 6.4 pc/liter. This does not include the 9.4 pc/liter results obtained on the Clinch River at Kingston, Tennessee, below the Oak Ridge National Laboratory, omitted so that the reported averages would indicate only the occurrence of strontium-90 due to fallout persisting from previous atmospheric nuclear detonations and possibly that supplemented by venting of recent underground tests at the Nevada Test Site (*3*). The eight sampling stations having values greater than this previously observed highest value of 6.4 pc/liter are listed in table 3. Total beta values (quarterly mean of monthly means of weekly samples) are listed for comparative purposes.

The PHS drinking water standards for radioactivity (*4*) give concentration limits and list a range of intake limits as set forth by the Federal Radiation Council (FRC). The limit for strontium-90 concentrations in drinking water is 10 pc/liter. While FRC range II daily intake rate for strontium-90 from all sources is 200 pc/day, daily intakes are prescribed with the provision that dose rates be averaged over a period of one year. The single value at Grand Forks in excess of 10 pc/liter can be considered a quarterly average in the raw water. It was not possible to calculate the annual average at Grand Forks because of the lack of previous samples. It is reasonable to assume, however, that this annual average is less than 10 pc/liter in light of the decreased level determined for the subsequent quarter and lower results found in samples from other surface streams in the north central area. Further, it is known that strontium-90 levels are reduced through water treatment processes such as elevation of pH and lime-soda softening.

TABLE 3.—QUARTERLY AVERAGE STRONTIUM-90 AND TOTAL BETA ACTIVITY AT THE EIGHT SAMPLING STATIONS WHOSE STRONTIUM-90 CONCENTRATIONS EXCEEDED 6.4 pc/liter, [a] JULY-DECEMBER 1963

[Concentrations in pc/liter]

Sampling stations	Strontium-90		Gross Beta	
	July-September	October-December	July-September	October-December
Arkansas River:				
Coolidge, Kans	6.6	—	658	46
Ponca City, Okla	6.5	4.4	208	115
Ft. Smith, Ark	6.7	—	252	67
Big Sioux River:				
Sioux Falls, S. Dak	9.5	5.0	133	47
Kansas River:				
Desoto, Kans	7.4	—	188	107
Mississippi River:				
St. Paul, Minn	7.2	4.3	62	30
Burlington, Iowa	7.3	4.3	47	28
Red River (North):				
Grand Forks, N. Dak	11.3	7.1	72	56

[a] Exceptions:

July-September 1962
Clinch River:
Kingston, Tenn 12.6

October-December 1962
Colorado River:
Page, Ariz 6.9

July-September 1963
Clinch River:
Kingston, Tenn 9.4

October-December 1963
Clinch River:
Kingston, Tenn 6.5

Total beta activity of suspended plus dissolved solids in surface water for the eight selected sampling stations is included in table 3. An increase in beta activity was noted at several of these stations as compared with established background levels. In the sample received from the Big Sioux River the overall increase was large percentagewise, *i.e.* a rise from 120 to 240 pc/liter or 100 percent from June to July 1963. The composite of samples for the month of July 1963 was found to have a beta activity of 130 ± 18 pc/liter of the suspended portion, even though the suspended solids amounted to only 181 mg/liter (*5*). By comparison, in the previous composite (June 1963) the beta activity was 48 ± 15 pc/liter in the suspended portion in which the suspended solids were 153 mg/liter (*6*).

On the Arkansas River at Coolidge, Kansas, two turbid samples showed substantially elevated beta activities; on August 21, 1963, with 3086 mg/liter suspended solids, the beta activity was 771 ± 129 pc/liter, and on September 3, 1963, with 2380 mg/liter suspended solids, the beta activity was 421 ± 108 pc/liter. The other samples collected weekly during these two months were appreciably lower in beta activity as reflected by the quarterly average (*7,8*). The dissolved alpha and beta activities were not significantly different from those commonly observed at this sampling point. Samples from other stations on this river indicated no unusual values. The samples associated with these elevated averages contained large quantities of suspended solids. Thus, only small aliquots could be used in the laboratory determinations in order to avoid excessive self-absorption. In such cases the relatively large multiplication factor, together with the usual range of counting error associated with standard counting periods can result in apparently abnormal levels of radioactivity. The specific activity (pc/g) of the sample discussed above was determined and found to be comparable to the specific activity observed normally in samples from these stations. The apparent increased activity, therefore, may be considered attributable to the extremely high suspended solids content of the samples and is essentially of natural origin.

Summary

Water samples collected during July-September 1963 had appreciably higher levels of strontium-90 than previous quarters. The highest strontium-90 levels were in the north central area of the conterminous States. One of these samples (Red River of the North at Grand Forks, N. D.) contained over 10 pc Sr^{90}/liter. Samples collected during the subsequent quarter (October-December 1963) were found to have lower levels of strontium-90. Relatively higher strontium-90 levels continued to be seen in the north central area.

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(*1*) American Public Health Association, American Water Works Association and Water Pollution Control Federation: *Standard Methods for the Examination of Water and Wastewater*, 11th Edition, New York (1960).

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(*3*) Martell, E. A., Iodine–131 Fallout from Underground Tests, *Science, 143:* 126–9 (January 10, 1964).

(*4*) Public Health Service: *Drinking Water Standards*, PHS Publication No. 956, Superintendent of Documents, U. S. Government Printing Office, Washington D. C. 20402 (Revised 1962), price 30 cents.

(*5*) Public Health Service: Radioactivity in Raw Surface Waters—National Water Quality Network, July 1963, *Radiological Health Data 5:* 31–35 (January 1964).

(*6*) Public Health Service: Radioactivity in Raw Surface Waters—National Water Quality Network, June 1963, *Radiological Health Data 4:* 615–618 (December 1963).

(*7*) Public Health Service: Radioactivity in Raw Surface Waters—National Water Quality Network, August 1963, *Radiological Health Data, 5:* 77–81 (February 1964).

(*8*) Public Health Service: Radioactivity in Surface Waters of the United States, September 1963, *Radiological Health Data 5:* 139–42 (March 1964).

Publication in earlier issues of *RHD:*

- *May 1960*
- *August 1960*
- *November 1960*
- *December 1960*
- *February 1961*
- *June 1961*
- *September 1961*
- *December 1961*
- *February 1962*
- *July 1962*
- *December 1962*
- *March 1963*
- *May 1963*
- *September 1963*
- *January 1964*

Section IV—Other Data

RADIOLOGICAL SURVEY OF THE LOWER COLUMBIA RIVER IN OREGON,[1] JANUARY 1962—JULY 1963

George L. Toombs and John G. Bailey[2]

The Lower Columbia River Radiological Survey in Oregon was initiated in June, 1961 and sample collection began in January 1962. The Survey is a joint effort of the Oregon State Board of Health and the Division of Radiological Health, U. S. Public Health Service.[3] The objectives of this survey were: (1) to determine the distribution of radionuclides in environmental media in the Columbia River area below Bonneville Dam and along the Oregon seacoast originating from the Hanford Atomic Products Operation and (2) to develop Oregon State Board of Health Laboratory and staff capabilities for conducting a comprehensive environmental radiation surveillance program.

Hanford is located on the upper Columbia River at Richland, Washington (see figure 1) and consists of a five-hundred square mile complex of nuclear reactors, fuel fabrication plants, chemical separation facilities, and research and development laboratories.

Hanford reactor cooling waters add radioactivity to the Columbia River at a rate of several thousand curies per day. Hanford conducts an extensive environmental radiation sur-

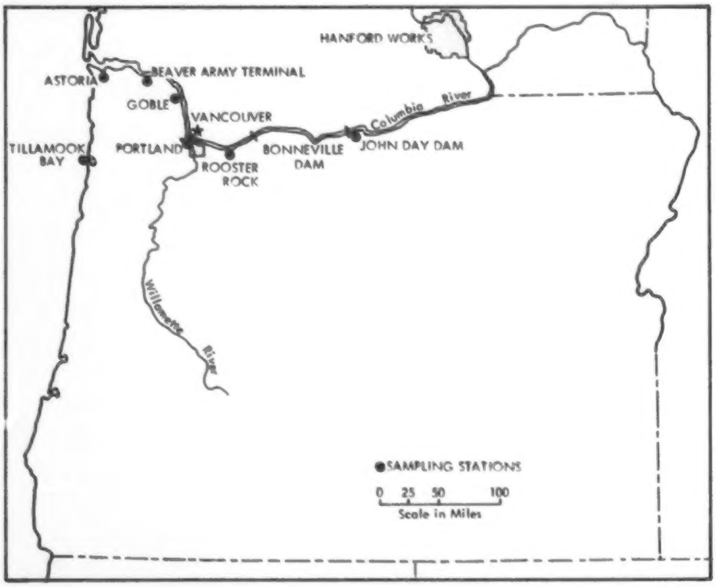
HANFORD WORKS
ASTORIA
BEAVER ARMY TERMINAL
GOBLE
VANCOUVER
TILLAMOOK BAY
PORTLAND
ROOSTER ROCK
BONNEVILLE DAM
JOHN DAY DAM
Columbia River
Willamette River
● SAMPLING STATIONS
0 25 50 100
Scale in Miles

FIGURE 1.—COLUMBIA RIVER STUDY SAMPLING LOCATIONS

veillance program; however, Vancouver, Washington, is the farthest downstream location where river water and biota are routinely sampled. These data together with data on radioactivity in U. S. surface water are routinely published in *Radiological Health Data* (*2,3*).

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[1] Summarized from original article by Toombs and Bailey (*1*).

[2] Mr. Toombs is Chief Radiochemist and Mr. Bailey is Radiation Health Specialist, Division of Sanitation and Engineering, Oregon State Board of Health.

[3] For other data concerning the Columbia River, see page 386 of this issue.

Sampling Program and Results

The following criteria were used in the selection of sampling locations: (1) availability of samples which could be used to describe the concentrations of the radionuclides present in the environment, (2) accessibility on a year round basis, and (3) avoidance of needless duplication of the sampling efforts of similar programs.

Generally samples were obtained on a monthly basis. Plastic bags were usually used for transportation and storage of all samples except water samples. Most of the biological samples were preserved by refrigeration.

A total of 44 water, 41 sediment, 53 algae, 23 crab, 15 oyster, 25 clam, 8 mussel, 5 sea anemone, and 6 miscellaneous samples were collected and analyzed. Tables 1, 2, and 3 summarize the results from only the primary sampling locations (see figure 1).

Two-liter water samples were collected in polyethylene containers. To prevent plating of the radionuclide onto the container surfaces and to keep dissolved substances in solution, two milliliters of concentrated hydrochloric or nitric acid were added. Table 1 shows the concentration of five radionuclides and total beta

TABLE 1.—SUMMARY OF RADIOACTIVITY IN COLUMBIA RIVER WATER SAMPLES, JANUARY 1962–JULY 1963

[Conceptrations in pc/liter]

Location (Columbia River)	Number of samples	Average Minimum-Maximum					
		Beta	K^{40}	Zn^{65}	Zr^{95}—Nb^{95}	Ru^{103}	Cr^{51}
John Day Dam	5	106 100–110	184 <170–581	47 <35–81	<13 <13–15	13 <10–25	3800 2700–5300
Rooster Rock	4	119 54–240	<170 <170–177	45 <35–74	28 <13–91	11 <10–24	2400 1700–3200
Goble	5	41 20–59	<170 <170–338	<35 <35–<35	<13 <13–22	<10 <10–14	1400 930–1800
Beaver Army Terminal	7	91 29–150	<170 <170–241	40 <35–61	<13 <13–19	<10 <10–<10	2000 1300–2600
Astoria	6	65 <10–160	<170 <170 <170	<35 <35–<35	<13 <13–16	<10 <10–13	1400 600–2000
Summary of five locations above	27	84 <10–240	<170 <170–581	<35 <35–81	<13 <13–91	<10 <10–25	2200 600–5300
Other location: Portland (Willamette R.)	9	<10 <10–13	<170 <170–<170	<35 <35	<13 <13–16	<10 <10–<10	<140 <140–<140

TABLE 2.—SUMMARY OF RADIOACTIVITY IN COLUMBIA RIVER SEDIMENT SAMPLES, JANUARY 1962–JULY 1963

[Concentrations in pc/gram wet but drained weight]

Location (Columbia River)	Number of samples	Average Minimum-Maximum			
		K^{40}	Zn^{65}	Zr^{95}—Nb^{95}	Ru^{103}
John Day Dam	8	30.4 11.9–52.0	30.6 1.2–82.1	3.1 0.3–8.9	2.0 0.2–4.5
Rooster Rock	4	12.8 7.0–15.7	0.8 0.2–1.4	4.1 0.7–7.8	1.1 0.3–1.8
Goble	4	31.9 14.5–73.5	64.3 5.2–230	10.9 2.2–35.0	5.4 0.9–17
Beaver Army Terminal	6	33.6 11.5–65.0	56.1 2.2–129	12.2 1.0–27.6	5.5 0.4–13
Astoria	1	28.9	62.9	16.1	6.0
Summary of five locations above	23	27.5 7.0–73.5	42.9 0.2–230	9.3 0.3–35.0	4.0 0.2–17

TABLE 3.—SUMMARY OF RADIOACTIVITY IN ENVIRONMENTAL MEDIA AT TILLAMOOK BAY, JANUARY 1962–JULY 1963

[Concentrations in pc/gram wet weight]

Type of sample	Number of samples	Average Minimum-Maximum			
		K^{40}	Zn^{65}	Zr^{95}—Nb^{95}	Ru^{103}
Water (pc/liter)	7	236 <170–655	<35 <35–<35	23 <13–78	<10 <10–14
Sediment	14	10.3 5.7–18.7	0.6 0.1–1.9	14.5 1.6–51.2	2.7 0.4–7.6
Algae:					
Fucus furcatus	10	7.2 1.4–18.4	0.5 0.2–1.4	8.7 0.9–19.0	2.2 0.1–6.3
Enteramorpha compressa	3	4.5 3.0–5.8	0.4 0.2–0.8	8.0 0.2–19.1	2.5 0.03–4.1
Dungeness Crab	12	2.0 <1.5–3.1	16.7 10.0–27.4	0.4 <0.1–1.4	0.2 <0.1–0.4
Pacific Oysters	13	2.0 1.1–3.1	23.8 7.1–52.0	0.3 <0.1–0.6	0.6 <0.1–0.9
Soft Shelled Clams	16	2.9 1.0–4.1	2.8 1.4–5.3	1.7 0.2–4.4	0.7 0.1–1.6

activity in the Columbia River water at five locations. Also included as an environmental background control are results from the Willamette River at Portland.

Sediment samples were collected by scooping up approximately one liter of the top inch of deposits. These samples were collected from the shallow water along the shoreline, except at Tillamook Bay where the samples were collected on a mud flat which was accessible at low tide. Table 2 summarizes the concentrations of radionuclides in bottom sediment from water sampling locations.

Water and sediment data from all locations have been summarized in row six of both tables. The averages and ranges given here are the totals for all analyses and the averages are obtained by averaging the individual station averages.

Other environmental samples were collected at points along the Oregon coast. Attached algae were picked or scraped from their growing sites and loose algae were hand gathered. Different species were collected and identified but only those collected at Tillamook Bay are reported. One-pound samples of fresh Dungeness crab meat (*Cancer magister*) were purchased from local producers who collect specimens in the sampling locations. One-pint samples of Pacific oysters (*Ostrea gigas*) were purchased from commercial growers who have oyster beds in the sampling locations. Three species of clams were obtained by digging in the mud flat areas at the sampling locations. Table 3 summarizes environmental data from Tillamook Bay, the primary sampling location.

Analytical Procedures

Samples were routinely analyzed within one week after collection. Water, sediment, and algae samples were gamma counted in their original state. The edible parts of crabs, clams, and oysters were counted with tissue liquid. The normal counting period was 100 minutes.

Gamma counting was done with a 3 x 3-inch sodium iodide thallium-activated scintillation crystal. In routine counting 256 channels (10 kev/channel) of a multichannel analyzer were used. Water samples consisting of 1.5 liters were counted in a Marinelli beaker. The counting of the environmental samples was usually performed on 400 ml of sample although 200 ml samples were occasionally used.

Calibration and counting efficiencies for the system were determined by the use of standard sources. To eliminate the contribution to a given photopeak from higher energy interfering radionuclides, Compton scatter corrections were calculated using the data from the standard radionuclide spectra. By approximating the portion of the count rate in the photopeak caused by Compton scattering due to the activity of the higher energy radionuclide, corrections were made for this interference. Corrections for radionuclides not in the analysis scheme

TABLE 4.—MINIMUM DETECTABLE CONCENTRATIONS FOR GAMMA-EMITTING RADIONUCLIDES IN ENVIRONMENTAL MEDIA

Media	Sample size	K^{40}	Zn^{65}	Zr^{95}—Nb^{95}	Ru^{103}	Cr^{51}	Units
Water	1.5 liters	170	35	13	10	100	pc/liter
Other	400 grams	1.0	0.2	0.06	0.01	—	pc/gram

were not made. However, their presence would cause the reported results to be higher than the true values.

The minimum detectable activity was considered to be that amount of activity which in the same counting time gave a count which was different from the background count by three times the standard deviation of the background count. This minimum detectable activity for water and other environmental samples is shown in table 4.

All values are reported as pc/gram wet or drained weight for biological and sediment samples and as pc/liter for water samples. All gamma activity concentrations are extrapolated to the date of collection.

For alpha and beta analyses of water, a 500-ml aliquot of the samples previously gamma-scanned was evaporated to dryness on a 2-inch planchet and counted in a gas-flow internal proportional counter utilizing a two-inch detector. The minimum detectable level for gross beta analyses is approximately 10 pc/liter and for gross alpha analyses is less than 1 pc/liter. Alpha and beta results are not corrected to the time of collection since the concentration of specific alpha- and beta-emitting radionuclides is not known. Due to the high concentrations of dissolved solids, sea water samples were omitted from the alpha and beta analyses.

Discussion

The sources of radioactivity in the areas covered by this survey were the Hanford works located on the upper Columbia River near Richland, Washington; USSR and United States atmospheric weapons testing; and naturally occurring radionuclides, principally potassium-40. Hanford works has eight single-pass production reactors which use treated Columbia River water for cooling. The effluent water from the reactors containing radionuclides is discharged back into the Columbia River. Some twenty radionuclides, formed principally by neutron activation, make up 98 percent of the radioactive material present in the reactor effluent (*4*). These radionuclides are transported approximately 350 miles by the Columbia River to the Pacific Ocean. Most of the Columbia River waters are carried predominantly northward by ocean currents. However, seasonally the Columbia River water flows southward along the Oregon seacoast. The radionuclides which appear as fallout from atmospheric nuclear weapons testing gain access to the Columbia River and Pacific Ocean by direct deposition and surface runoff.

The radionuclide data presented in this report do not represent all of the radionuclides present in the sample. Utilizing gamma spectrometry and half-life decay characteristics, with limited sample preparation, the following radionuclides could be identified in the samples analyzed during this survey: Ce^{141}, Ce^{144}, Np^{239}, Co^{60}, Ru^{103} + Ru^{106}, Ba^{140} + La^{140}, Mn^{54}, Zr^{95} + Nb^{95}, Cr^{51}, Zn^{65}, and K^{40}. The radionuclides Ru^{103} + Ru^{106}, Zr^{95} + Nb^{95}, Cr^{51}, Zn^{65}, and K^{40} could be identified and their concentrations determined with sufficient confidence to warrant reporting. The activation-product radionuclides, Zn^{65} and Cr^{51}, were detected only in environmental samples from the lower Columbia River and Oregon seacoast. The fission product radionuclides, Ru^{103} + Ru^{106} and Zr^{95} + Nb^{95} were detected in all environmental samples with peak values generally observed during the spring of 1963.

Water: Gross alpha concentrations for the Columbia River water samples collected in connection with this survey were all less than 1 pc/liter, indicating the absence of detectable alpha activity.

The gross beta concentrations in the Columbia River water samples were observed to generally decrease with increasing distance from the Hanford reactors. The data tended to confirm the expected decrease in concentrations during the summer months because of high dilution as the result of the increased summer flows in the Columbia River. Average values for beta activity in water decreased from 106 pc/liter at John Day Dam to 38 pc/liter at Astoria. During a similar time period the average beta activity in the Willamette River at Portland was less than 10 pc/liter.

Generally, concentrations of most gamma-emitting radionuclides in water samples were below the minimum detectable limits of the analytical procedures at all locations sampled below Beaver Army Terminal. The major exception was chromium–51. The average chromium–51 concentration decreased from 3800 pc/liter at John Day Dam to 1400 pc/liter at Astoria. Chromium–51 was not detected in water samples obtained along the Oregon coast or from the Willamette River at Portland. Zinc–65 was usually detectable in water samples from Beaver Army Terminal and other sampling locations upstream. Zinc–65 concentrations in water samples ranged from less than 35 to 81 pc/liter. These results were below maximum permissible concentrations, recommended by the International Commission on Radiological Protection (*5*). For water from all dietary sources, the following ICRP standards are given for the population at large: Zn^{65}, 10,000 pc/liter; Zr^{95}, 20,000 pc/liter; Ru^{103}, 27,000 pc/liter, Cr^{51}, 670,000 pc/liter.

Sediments: Bottom sediments contained comparatively high concentrations of radioactivity. Radionuclide concentrations in the sediment samples collected during this survey showed no trend with respect to distance by water from Hanford reactors. It appears that the radioactivity concentrations observed depends as much or more upon the characteristics of the sediment sampled and sampling technique as it does upon its distance from Hanford. Zinc–65 concentrations in sediment samples from Tillamook Bay remained relatively stable with respect to time at approximately 0.6 pc/gram drained weight. The fission products, zirconium-niobium–95 and ruthenium–103 + 106, reached a definite peak (value) in concentrations during the spring of 1963.

Biological Organisms: These organisms metabolize a wide variety of chemical elements, including the available radioisotopes of the elements. The extent of concentration varies with the organism's requirement for an element, its availability, and chemical form.

Potassium–40 was detected in all of the biological organisms. Potassium–40 has an abundance in natural potassium of about 0.0119 percent. Biological organisms, except for algae, were found to have potassium–40 concentrations of approximately 3 pc/gram weight. Fresh water algae potassium–40 concentrations were about 40 pc/gram wet weight and the marine algae concentrations about 7 pc/gram wet weight

Zinc–65 was detected in all biological organisms collected from the Lower Columbia River and Oregon seacoast. The observed generalized trend for zinc–65 concentrations with respect to time remained relatively stable in the biological samples collected at the respective locations. The zinc–65 concentrations decreased with distance from the Hanford works. The edible shellfish, oysters and crabs had the highest average concentrations of zinc–65 (about 25 pc/gram wet weight). Soft shelled clams had average concentrations of 3 pc/gram wet weight.

Detectable concentrations of the fission product radionuclides, ruthenium–103 + 106 and zirconium-niobium–95, were also found in the biological organisms. Concentrations of these radionuclides generally reached a peak during the spring of 1963. Average concentrations of these radionuclides in crabs, oysters, and clams were less than 2 pc/gram wet weight.

Although significant concentrations of the radionuclide zinc–65 appeared in oysters and crabs, the amount of zinc–65 consumed by the public from eating these shellfish would be far below the maximum permissible intake. Use of the guides, recommended by the International Committee on Radiation Protection for total body exposure for the general population, implies a permissible intake rate of 8×10^6 pc of zinc–65 per year. The average concentration of zinc–65 was about 25 pc/gram in edible portions of crab and oyster samples collected during this survey. This permissible intake value of 8×10^6 pc would be reached after consuming about 700 pounds of crab and/or oysters per year, or approximately 2 pounds per day over a one-year period.

Conclusions

Concentrations of radionuclides arising from the Hanford reactors and atmospheric nuclear weapons testing were readily detected in the environmental media in the area covered by this survey. Certain trends were generally seen for fission product and activation product radionuclide concentrations. Zinc–65 and chromium–51 concentrations were observed to decrease with increasing distance by water from the Hanford reactors, and to remain relatively stable with respect to time. The fission-product radionuclides, zirconium–niobium–95 and ruthenium–103 + 106, did not show a trend with respect to distance from the Hanford reactors. However, with respect to time, they did show a generalized peak during the spring of 1963, probably due to the heavy fallout accompanying the spring rains. All concentrations for the radionuclides reported were below those recommended by the International Committee on Radiation Protection and Measurements for the general public. The radionuclide concentrations measured during this survey warrant no action other than continued surveillance to insure that the levels of radioactivity in this environment are neither too high nor increasing too rapidly.

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(*2*) General Electric Company: Environmental Levels of Radioactivity at Atomic Energy Commission Installations, Hanford Atomic Products Operations, Calendar Year 1962, *Radiological Health Data. 5:* 40–42.

(*3*) Public Health Service: Radioactivity in Surface Waters of the United States, August 1963, *Radiological Health Data, 5:* 77–81 (February 1964).

(*4*) Foster, R. F. (Edited by I. C. Nelson): *Evaluation of Radiological Conditions in the Vicinity of Hanford for 1961,* HW 71999 (March 1, 1962.) Office of Technical Services, Department of Commerce, Washington, D.C. 20230, price $3.50.

(*5*) International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation.* Pergamon Press, New York (1959).

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U. S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required. Summaries of the environmental radioactivity data for 23 AEC contractor installations have appeared periodically in *RHD* since November 1960. Following are reports for Argonne National Laboratory and Savannah River Plant.

Releases of radioactive materials from these plants for the periods covered in the reports below may be compared with standards set forth in the Federal Register, Title 10, Part 20. The appropriate concentration standards are given in table 1. Total alpha data in the Argonne and Savannah reports may be compared with the standards on line 2 in table 1. Total beta activity may be compared with lines 1 and 3. Additionally the Federal Radiation Council daily intake guides for iodine–131, strontium–89, and strontium–90 are noted.

TABLE 1.—CONCENTRATION STANDARDS [a] PERTAINING TO ENVIRONMENTAL MONITORING AT ARGONNE NATIONAL LABORATORY AND SAVANNAH RIVER PLANT

Line No.	Radionuclide or mixture of radionuclides	Environmental MPC's Water (pc/liter)	Environmental MPC's Air (pc/m ^{3})
1	If Sr^{90}, I^{129}, Pb^{210}, Po^{210}, Ra^{223}, Ra^{226}, Ra^{228}, Pa^{231}, and Th-nat are not present [b]	2,000	—
2	Mixtures of unidentified nuclides	10	0.04
3	If α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{231}, Pu^{241}, Bk^{249} are not present [b]	—	100
4	Barium-lanthanum-140	20,000	4,000
5	Cerium-141	90,000	5,000
6	Cerium-144	10,000	300
7	Cesium-137	20,000	500
8	Cobalt-58	90,000	2,000
9	Cobalt-60	50,000	300
10	Hydrogen-3 (tritium)	3,000,000	500,000
11	Iodine-131 [c]	2,000	300
12	Plutonium-239	5,000	0.06
13	Ruthenium-103	80,000	20,000
14	Ruthenium-rhodium-106	10,000	200
15	Strontium-89 [c]	10,000	1,000
16	Strontium-90 [c]	100	10
17	Thorium-232	2,000	1
18	Thorium-protactinium-234	20,000	2,000
19	Uranium, natural	20,000	2
20	Xenon-133	—	300
21	Zirconium-niobium-95	60,000	1,000

[a] The concentration standards given here were taken from the Atomic Energy Commission's regulation 10CFR. Part 20 (Federal Register, November 17, 1960).

[b] "Not present" implies that the concentration of the nuclide is small (<10%) compared with its appropriate MPC. See Federal Register, Title 10, Part 20, August 9, 1961.

[c] Daily intake guides recommended by the Federal Radiation Council (top of range II) are: iodine-131, 100 pc/day; strontium-89, 2000 pc/day; and strontium-90, 200 pc/day.

1. Argonne National Laboratory Calendar Year 1963

University of Chicago,
Lemont, Illinois

Air Monitoring

Weekly continuous air filter samples were collected at 7 locations on the Argonne National Laboratory (ANL) site as shown in figure 1 and at 5 offsite locations at Aurora (west of ANL site), Wheaton (northwest), Hinsdale (northeast), Joliet (southwest), and Tinley Park (southwest). The quarterly averages of alpha, beta, and several nuclide concentrations are given in table 2. The radionuclide determinations were made from gamma spectra of monthly composites of the filters. The data show little difference between offsite and onsite measurements for alpha activity and most of the nuclides, inferring that ANL does not contribute detectable quantities of these activities to the atmosphere. The average airborne beta activity during 1963, 5.7 pc/m^3, was approximately 1 pc/m^3 higher than 1962.

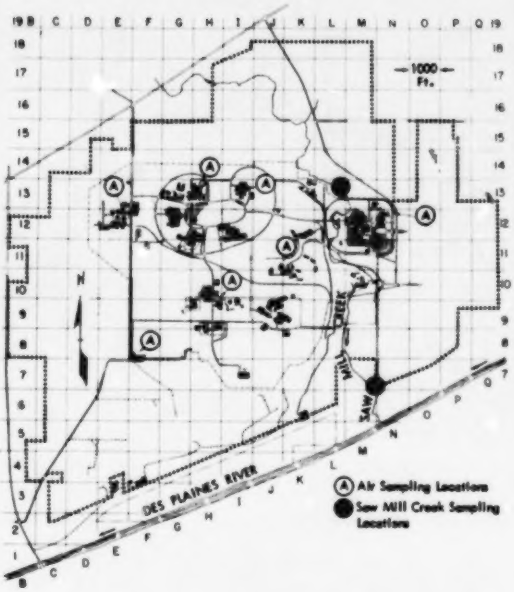

FIGURE 1.—ONSITE SAMPLING LOCATIONS, ARGONNE NATIONAL LABORATORY

TABLE 2.—RADIOACTIVITY OF AIRBORNE PARTICULATES, ANL, 1963

[Concentrations in pc/m^3]

Type of analysis	Sampling locations	1963 Quarterly Averages				1963 Average
		First Quarter	Second Quarter	Third Quarter	Fourth Quarter	
Alpha	On-site	0.0047	0.0064	0.0055	0.0057	0.0056
	Off-site	0.0051	0.0067	0.0055	0.0056	0.0057
Beta	On-site	6.8	9.6	5.0	1.3	5.6
	Off-site	7.1	9.6	4.9	1.3	5.7
Ba-La^{140}	On-site	0.42	<0.01	<0.01	<0.01	0.12
	Off-site	0.38	<0.01	<0.01	<0.01	0.11
Ce^{141}	On-site	0.20	1.5	0.6	<0.5	1.0
	Off-site	0.22	1.3	0.6	<0.5	1.0
Ce^{144}	On-site	1.8	3.7	2.2	0.58	2.1
	Off-site	2.1	4.4	2.0	0.61	2.3
Cs^{137}	On-site	0.06	0.18	0.10	0.03	0.10
	Off-site	0.06	0.20	0.10	0.04	0.10
Ru^{103}	On-site	0.77	0.65	0.16	<0.05	0.41
	Off-site	0.83	0.77	0.16	<0.05	0.45
Ru-Rh^{106}	On-site	0.76	1.9	0.86	0.26	0.93
	Off-site	0.76	2.0	0.78	0.25	0.97
Zr-Nb^{95}	On-site	3.1	4.4	1.50	0.22	2.3
	Off-site	3.2	4.6	1.40	0.21	2.4

Water Monitoring

ANL waste water is discharged into Sawmill Creek, a stream that runs through the Argonne grounds and enters the Des Plaines River about 500 yards downstream from the waste water discharge. Sampling locations on Sawmill Creek and Des Plaines River are shown in figures 1 and 2, respectively.

On Sawmill Creek, weekly grab samples are collected upstream and 3 times a week samples are collected downstream from the waste water outfall. The upstream flow is roughly equal to the waste water flow, yielding a dilution factor of one-half. The data in table 3 show significantly higher concentrations downstream than upstream, an indication of the radioactivity contributed to the stream by ANL. A comparison of the downstream concentrations with the environmental MPC's listed in table 1 shows that all concentrations are relatively low.

Weekly grab samples are collected from the Des Plaines River upstream and downstream from its junction with Sawmill Creek. The results indicate that the dilution factor of the Des Plaines River is so large that the radioactivity contribution from ANL was not detected.

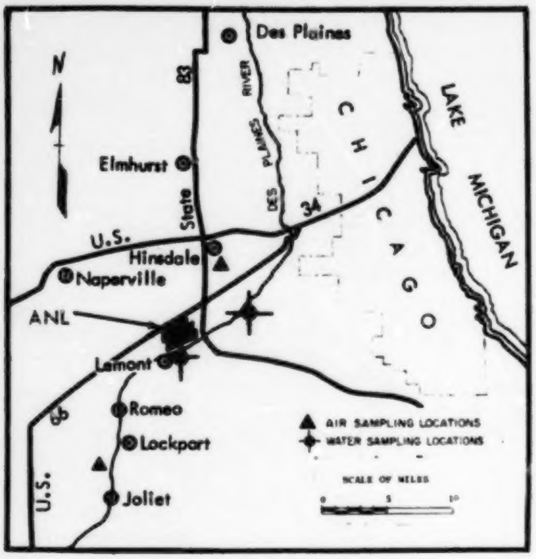
Des Plaines
N
83
RIVER
DES PLAINES
CHICAGO
LAKE MICHIGAN
Elmhurst
State
34
U.S.
Hinsdale
Naperville
ANL
Lamont
66
Romeo
Lockport
Joliet
U.S.
AIR SAMPLING LOCATIONS
WATER SAMPLING LOCATIONS
SCALE OF MILES
0
5
10

FIGURE 2.—SITE LOCATION OF ARGONNE NATIONAL LABORATORY (INCLUDING SOME OFFSITE SAMPLING STATIONS)

Previous coverage in *Radiological Health Data:*

Period	Issue
1959 and first quarter 1960	*December 1960*
Second quarter 1960	*April 1961*
Third and fourth quarters 1960	*July 1961*
First and second quarters 1961	*December 1961*
Third and fourth quarters 1961	*May 1962*
1962	*May 1963*

TABLE 3.—RADIOACTIVITY IN SAWMILL CREEK, ANL 1963

[Concentrations in pc/liter]

Type of analysis	Sampling location	First half 1963			Second half 1963		
		Maximum	Minimum	Average	Maximum	Minimum	Average
Alpha emitters:							
Total alpha	Upstream	6.5	0.3	1.8	4.1	0.1	1.4
	Downstream	10.1	1.3	3.8	11.8	1.1	4.4
U-natural	Upstream	1.7	0.4	1.1	1.5	0.9	1.3
	Downstream	6.7	0.8	2.5	8.0	1.2	2.8
Pu^{239}	Upstream	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Downstream	0.94	<0.05	0.4	1.2	<0.05	0.27
Th^{232}	Upstream	0.17	<0.05	0.07	0.15	<0.05	0.10
	Downstream	1.0	<0.05	0.19	0.40	<0.05	0.12
Beta emmitters:							
Total beta	Upstream	489	9	84	188	9	31
	Downstream	169	24	68	192	13	38
Co^{58}	Upstream	<5	<5	<5	<5	<5	<5
	Downstream	27.4	<5	6.4	30	<5	6
Co^{60}	Upstream	<2	<2	<2	<3	<3	<3
	Downstream	4	<2	1.0	20	<3	2
Sr^{89}	Upstream	30.3	<2	10.0	18.9	<2	3.8
	Downstream	67.0	<2	9.7	10.1	<2	2.0
Sr^{90}	Upstream	5.3	<0.5	3.0	8.5	1.4	3.1
	Downstream	9.4	<0.05	2.6	7.0	<0.5	1.2
I^{131}	Upstream	<3	<3	<3	[a] —	—	—
	Downstream	45	<3	3.5	78	<3	5
Cs^{137}	Upstream	2.1	<0.5	0.8	<0.5	<0.5	<0.5
	Downstream	10.5	0.6	3.1	5.2	0.8	2.2
Ba^{140}	Upstream	6.6	<2	1.2	<2	<2	<2
	Downstream	20.3	<2	1.4	<2	<2	<2
$Th\text{-}Pa^{234}$	Upstream	1.4	0.3	0.9	1.6	0.7	1.0
	Downstream	5.4	0.6	1.5	5.9	0.6	1.7

[a] Dash means no analysis.

104

2. Savannah River Plant
Calendar Year 1963

E. I. du Pont de Nemours
Aiken, South Carolina

The Savannah River Plant (SRP) maintains a continuous monitoring program to determine the concentrations of radioactive materials in a 1200-square-mile area outside the plant perimeter. Included in this area are parts of Aiken, Barnwell, and Allendale Counties in South Carolina and Richmond, Burke, and Screven Counties in Georgia. This program, initiated in 1951 prior to plant operations, is carried out by the Health Physics Section of E. I. du Pont de Nemours and Company, prime contractor for operation of the plant for the Atomic Energy Commission.

Although SRP discharges some gaseous and liquid waste to the environment, the releases are controlled to assure adequate dispersal so that offsite concentration of radioactive materials is below the Radioactivity Concentration Guides (MPC) shown in table 1. Continuous surveillance of the Savannah River Plant provides information useful both as a measure of the effectiveness of plant controls and as evidence of the strict adherence to the recommended MPC.

Atmospheric Monitoring

Continuous air and rainwater samples are collected at 15 monitoring stations. These stations, which include 5 locations (A–E) at the plant perimeter and 10 locations approximately 25 miles from the center of the plant are spaced so that a measurable plant release of radioactivity to the air would be detected regardless of prevailing wind conditions (see figure 3). Four additional air monitoring stations are

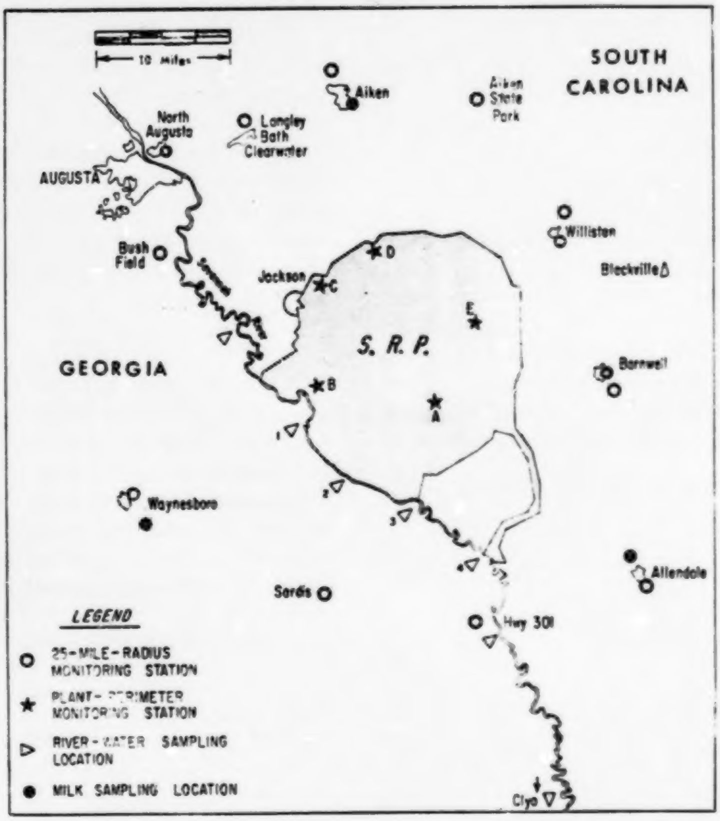
10 Miles
SOUTH CAROLINA
Aiken
Aiken State Park
North Augusta
Langley Bath Clearwater
AUGUSTA
Williston
Bush Field
D
Jackson
C
Blackville
E
S. R. P.
GEORGIA
Barnwell
B
A
1
2
3
4
Waynesboro
Allendale
Sardis
Hwy 301
Clyo
LEGEND
25-MILE-RADIUS MONITORING STATION
PLANT-PERIMETER MONITORING STATION
RIVER-WATER SAMPLING LOCATION
MILK SAMPLING LOCATION

FIGURE 3.—ENVIRONMENTAL SAMPLING LOCATIONS, SAVANNAH RIVER PLANT

operated approximately 100 miles from the plant at Savannah and Macon, Georgia, and Columbia and Greenville, South Carolina (see figure 4). At this distance, the effect of SRP operations is minimal, and therefore, these facilities serve as "reference points" for determining background levels of activity. The complete system of 19 stations permits a comprehensive surveillance of atmospheric radioactivity and differentiation between weapons testing fallout and plant releases. The average concentrations of radioactivity in air are given in table 4.

TABLE 4.—RADIOACTIVITY IN AIR

[Average concentrations in pc/m³]

Period	Source of samples	Alpha	Non-volatile beta	Iodine-131
First half 1963	Plant perimeter	0.0010	5.6	0.02
	25-mile radius	0.0012	6.2	0.02
	100-mile radius	0.0015	6.2	0.02
Second half 1963	Plant perimeter	0.0011	1.7	<0.02
	25-mile radius	0.0011	1.8	<0.02
	100-mile radius	0.0012	1.8	<0.02

The levels of radioactivity observed in air and in rainwater were attributed to fallout, as the radioactivity concentrations showed no correlation to plant releases.

Milk

Milk samples were collected from dairies and farms within a 50-mile radius of the plant, and were analyzed weekly for tritium and iodine-131 and monthly for strontium-90. Average concentrations for tritium, iodine-131 and strontium-90 are given in table 5.

The estimated exposure to a child's thyroid for calendar year 1963 from consumption of one liter of local dairy milk per day was less than 25 percent of 0.5 rem per year guidance value suggested by the Federal Radiation Council. The exposure to an adult would be one-tenth that of a child on a thyroid weight basis.

TABLE 5.—RADIOACTIVITY IN MILK

[Average concentrations in pc/liter]

Analysis (Sensitivity)	Number of Locations	First half 1963	Second half 1963
Tritium (3000 pc/liter)			
Farms	4	5300	[a]—
Local dairies	6	<3900	3600
Major distributors	1	3700	3000
Iodine-131 (2 pc/liter)			
Farms	4	23	[a]—
Local dairies	6	7	<11
Major distributors	1	6	<11
Strontium-90 (1 pc/liter)			
Farms	5	45	[a]—
Local dairies	6	[b] 13	27
Major distributors	3	[b] 19	32

[a] Dash denotes no samples collected.
[b] March 1963.

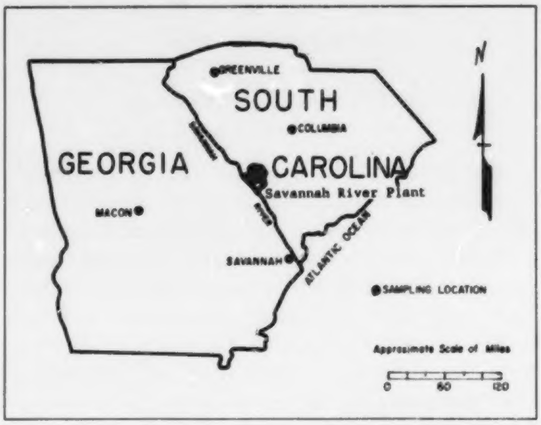

FIGURE 4.—DISTANT AIR MONITORING STATIONS, SAVANNAH RIVER PLANT

The higher concentrations of strontium-90 in milk of farm cows were attributed to the feeding habits. These cows generally received little commercial feed but grazed on topshoots or shallow-rooted grasses, both susceptible to fallout contamination. Dairy cows, on the other hand, received less pasture grass and more dried silage and commercial feed. The same relationship seems to be true for tritium and iodine-131.

Vegetation

Bermuda grass, because of its importance as a pasture grass for dairy herds and its year-round availability, was selected for analysis of radioactive contamination.

Average concentrations of alpha emitters and nonvolatile beta emitters found on vegetation collected at the air monitoring locations shown in figure 4 are summarized in table 6.

TABLE 6.—RADIOACTIVITY IN VEGETATION (BERMUDA GRASS)

[Average concentrations in pc/gm]

Period	Source of sample	Alpha	Gamma emitters
First half 1963	Plant perimeter	0.23	683
	25-mile radius	0.21	804
Second half 1963	Plant perimeter	0.14	158
	25-mile radius	0.14	138

Algae and Fish in Savannah River

Determination of radioactivity concentrations in algae is important because algae are concentrators of specific radionuclides and also have an important relationship in the food chain of aquatic organisms. Indigenous algae samples were collected weekly upstream from, adjacent to, and downstream from the plant. The average non-volatile beta concentrations are given in table 7. Some correlation of the plant effluent entry into the river is indicated by the lower upstream values. Fish taken from the river showed negligible plant-contributed radioactivity.

TABLE 7.—NONVOLATILE BETA IN SAVANNAH RIVER ALGAE AND FISH

[Average concentrations in pc/gm]

Period	Location	Nonvolatile beta	
		Algae	Fish (flesh)
First half 1963	Adjacent to plant	165	4
	Upstream (3 mi.)	80	4
	Downstream (10 mi.)	80	5
Second half 1963	Adjacent to plant	150	4
	Upsteam (3 mi.)	60	3
	Downstream (10 mi.)	95	3

Water Monitoring

Communities in the vicinity of SRP obtain water from deep wells or surface streams. Public water samples are collected monthly from 14 surrounding towns. The Savannah River is sampled continuously at 7 locations. Six of the locations are shown in figure 3; the seventh is 60 miles downstream from the plant.

Average concentrations of alpha and beta activity in public and Savannah River water are presented in table 8. The values shown indicate that plant operations contribute small amounts of radioactivity to the Savannah River, and the resulting concentrations are far below MPC.

Specific analyses for certain radionuclides in river water were made for the first time during 1963 by gamma spectroscopy. River water was analyzed previously for iodine-131 by chemical separation. Radionuclides in river water upstream and downstream from the plant during the year are shown in figure 5 and table 9; the values represent the quantities of radionuclides passing the two sample points.

TABLE 8.—RADIOACTIVITY IN WATER

[Average concentrations in pc/liter]

Period	Source of samples	Alpha	Non-volatile beta	H^3	Sr^{90}
First half 1963	Public water supplies	1.4	8	[a]—	—
	Savannah River water				
	3 miles upstream	>0.2	27	600	0.8
	10 miles downstream	>0.2	38	18,000	1.14
Second half 1963	Public water supplies	1.6	8	—	—
	Savannah River water				
	3 miles upstream	>0.2	14	1,200	1.1
	10 miles downstream	>0.2	20	9,600	1.6

[a] Dash indicates no analysis.

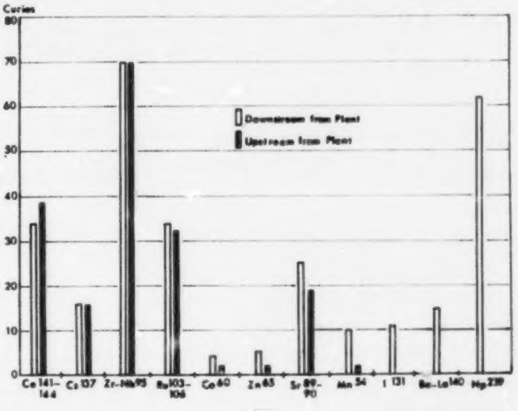

FIGURE 5.—RADIONUCLIDES IN TRANSPORT IN RIVER WATER, JANUARY-JUNE 1963

TABLE 9.—AVERAGE CONCENTRATION OF RADIONUCLIDES IN SAVANNAH RIVER WATER, 1963

[pc/liter]

Radionuclide	Sensitivity of analysis	Control (3 miles upstream from plant)	10 miles downstream from plant
$Ce^{141,144}$	2.5	5.8	6.0
Cs^{137}	0.6	2.8	3.3
$Zr\text{-}Nb^{95}$	0.5	8.0	7.9
$Ru^{103,106}$	3.2	6.5	6.6
Co^{60}	1.4	1.8	2.1
Zn^{65}	1.1	1.6	1.9
Sr^{89}	0.3	3.2	4.6
Sr^{90}	0.01	1.0	1.4
Mn^{54}	0.4	0.7	1.0
I^{131}	0.5	[a]—	2.5
$Ba\text{-}La^{140}$	1.6	[a]—	4.5
Np^{239}	0.9	[a]—	18.0
Cr^{51}	4.3	[a]—	27.0
H^3	600	900	13,800

[a] Less than sensitivity of analysis.

Np^{239}, I^{131}, $Ba\text{-}La^{140}$ and Cr^{51} constituted the primary gamma-emitting radionuclides from the plant. These radionuclides, primarily from the reactor areas, decay rapidly after their formation because of their short half lives (<30 days).

107

Most of the longer lived materials came from fallout.

In no instance was the concentration of any radionuclide in river water more than 4.6 percent of its respective MPC.

External Gamma Radiation Levels

Environmental gamma radiation levels are measured by portable ion chamber dosimeters at each of the 15 air monitoring stations shown in figure 3. The average gamma radiation doses for calendar year 1963 were 0.48 mr per 24 hours at the plant perimeter stations and 0.45 mr per 24 hours at the 25 mile radius stations.

Discussion

During 1963, the levels of radioactivity released to the environs by the SRP were for the most part too low to be distinguished from natural background radiation levels, or were obscured by world-wide fallout from nuclear weapons testing.

Previous coverage in *Radiological Health Data:*

Period	Issue
1959 and first quarter 1960	*December 1960*
Second and third quarters 1960	*May 1961*
Fourth quarter 1960	*August 1961*
First and second quarters 1961	*February 1962*
Third and fourth quarters 1961	*September 1962*
Calendar year 1962	*August 1963*

NEVADA TEST SITE—OFF-SITE SURVEILLANCE OF ACCIDENTAL RELEASES, OCTOBER 1962—MARCH 1964.

Atomic Energy Commission[1]

Since the resumption of nuclear testing by the United States, September 15, 1961, the Atomic Energy Commission has announced 122 detonations at the Nevada Test Site through June 30, 1964. Of these 122 detonations, 116 were designed to be contained (eight tunnel experiments and 108 other underground detonations). Ten detonations designed to be contained accidentally released sufficient radioactivity to be measured off the Nevada Test Site and the contiguous Nellis Air Force Range. (Five of these were tunnel experiments.) Only three of these ten detonations occurred in the past eighteen months.

Previous issues of *Radiological Health Data* have contained data on these events up through June, 1962, that have released sufficient amounts of radioactive material to be measured off the Nevada Test Site and the contiguous Nellis Air Force Range. The present report summarizes findings of the U. S. Public Health Service off-site monitoring survey for four of the events since June 1962; i.e., October 19, 1962 (Bandicoot), June 5, 1963 (Yuba), December 12, 1963 (Eagle) and March 13, 1964 (Pike).

Bandicoot

The Bandicoot event was a low yield,[2] underground test detonated October 19, 1962. Airborne radioactivity rose to an altitude of approximately 6,500 feet above the surface. Yucca Weather Station observations at 1100 hours PDT showed the winds in the lower 2,000 feet above the surface to be light and variable with components to the north, east, and south. Winds above this layer were from the north and their speed increased with altitude from 13 to 35 mph up to 12,000 feet above mean sea level (approximately 8,000 feet above the surface).

The lower portion of the cloud which drifted northward was dispersed in the valleys north of the test site. No known exposures to people were involved in the northern off-site segment.

The upper portion of the cloud was carried south from ground zero over Cactus Springs, Indian Springs, and Lathrop Wells, Nevada. The highest instrument reading detected by ground monitors was 20 milliroentgens per hour (mr/hr). This reading was taken seven miles west of the Mercury turnoff on Highway 95 approximately 3½ hours after the detonation. The monitor who measured this dose rate estimated that this dose rate represented peak activity during cloud passage over Highway 95.

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[1] This article is presented as a contribution from the U.S. Atomic Energy Commission.

[2] Low yield is defined as less than 20 kilotons.

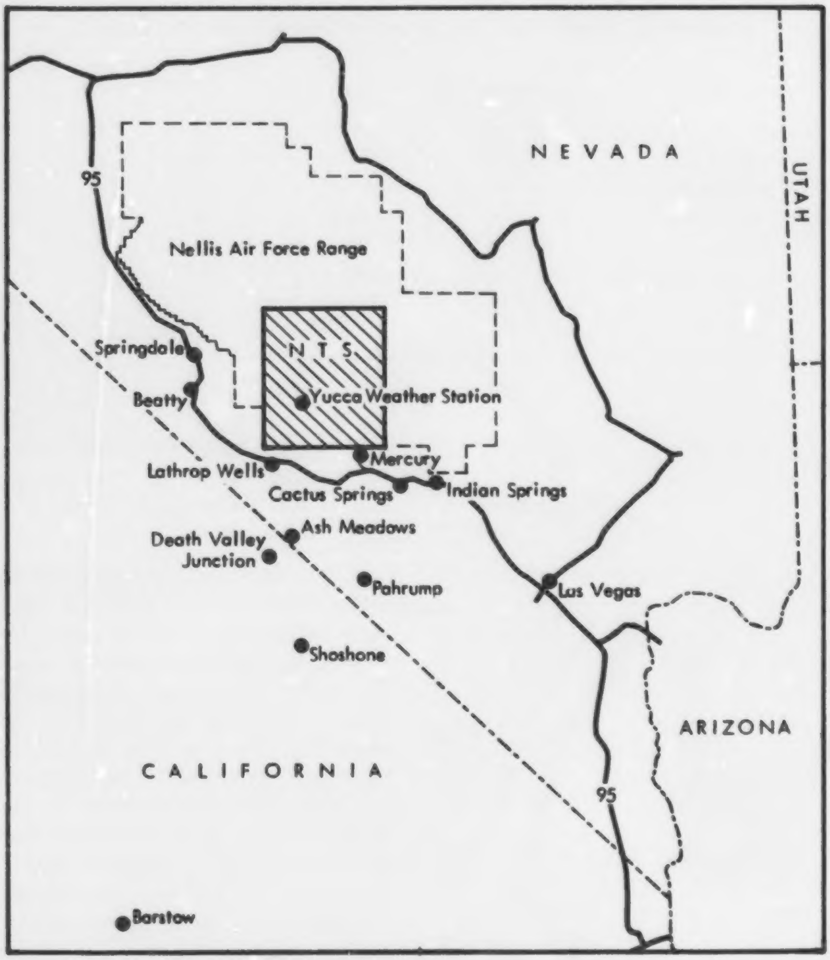
NEVADA
UTAH
95
Nellis Air Force Range
NTS
Springdale
Beatty
Yucca Weather Station
Lathrop Wells
Mercury
Cactus Springs
Indian Springs
Ash Meadows
Death Valley Junction
Pahrump
Las Vegas
Shoshone
ARIZONA
CALIFORNIA
95
Barstow

FIGURE 1.—MONITORING LOCATIONS IN THE VICINITY OF THE NEVADA TEST SITE

The cloud was first detected over Highway 95 approximately two hours after detonation. The highest instrument readings at ground level in populated areas were approximately 0.6 mr/hr at Cactus Springs, Nevada, 36 miles from ground zero, and Ash Meadows, Nevada, 49 miles from ground zero.

Increased gross beta activity was detected on the air filters at nine of the 16 downwind air sampling stations (figure 1) of the Nevada Test Site. Activity was extrapolated to midpoint of collection time. Findings at the highest stations are given in table 1. None of the levels in table 1 represent a measurable dose to the body.

All station film badges and personnel film badges worn by residents in the off-site area indicated below detectable limits; i.e., <30 mr.

The highest levels of iodine–131 found in milk samples collected from stations in the downward area are given in table 2.

Yuba

The Yuba event was a low yield, underground test detonated in a tunnel on June 5, 1963. On the day of the event no radioactivity above background levels was detected in the off-site area by ground or aerial monitoring teams or by air sampling.

109

TABLE 1.—MONITORING RESULTS AT THE SEVEN STATIONS WHERE HIGHEST READINGS WERE FOUND AFTER BANDICOOT EVENT

[Concentrations in pc/m³]

Station	Collection Period	Gross Beta	Collector [1]	I^{131}	I^{133}	I^{135}
Beatty	1200/19th to 0900/20th	1,050	F	27	D	490
Cactus Springs	1805/19th to 1127/20th	2,300	F	74	D	340
			C	9	46	900
Death Valley Junction	1538/19th to 1630/19th	52,000	F	102	D	345
Indian Springs	1840/19th to 1158/20th	2,300	F	69	D	570
			C	7.2	160	270
Lathrop Wells	1530/19th to 0630/20th	6,700	F	270	D	D
			C	44	D	2,500
Pahrump	1350/19th to 1300/20th	2,000	F	36	D	370
			C	6.2	D	140
Shoshone	1615/19th to 1205/20th	1,040	F	35	D	330
			C	5.2	D	18

[1] F-glass fiber filter; C-Charcoal cartridge; D-detected, but not quantitated.

TABE 2.—HIGHEST IODINE-131 CONCENTRATIONS IN MILK SAMPLES DOWNWIND OF BANDICOOT EVENT

Station	Date of collection	Iodine-131 concentration [1] (pc/liter)
Barstow, California	10/23/62	130
Barstow, California	11/02/62	110
Barstow, California	11/12/62	20
Springdale, Nevada	10/23/62	160
Springdale, Nevada	10/30/62	140
Pahrump, Nevada	10/23/62	40

[1] Atmospheric tests were being conducted by the United States (Pacific) and the USSR. The iodine-131 content of milk in the U.S. Public Health Service Pasteurized National Milk Network of October 1962, indicated that 12 stations in the U.S. submitted milk samples that were 100 pc/liter or above. The network average for iodine-131 in milk October 1962, for the U.S., was 62 pc/liter. Activity was extrapolated to date of collection.

Monitoring teams entered the tunnel a short time following the Yuba event and determined safe working times for re-entry personnel who were required to recover test data at the earliest possible time after detonation. On the day after the original entry into the tunnel, a release of iodine–131 was detected by radiation monitors who were supporting the data recovery operation. A few days later, a small amount of iodine–131 was also detected on an activated charcoal cartridge of an air filter located at Lathrop Wells, Nevada. The amount was too minute to be quantitated. No unusual levels of gross beta air activity appeared at any of the 32 routine air sampling stations surrounding the Nevada Test Site (to a distance of about 180 miles) following the test.

Eagle

The Eagle event was a low yield, underground test detonated December 12, 1963. Gaseous material that was released following the detonation moved south-southwest from ground zero at a wind speed of approximately 12 mph. The estimated height of the cloud was 1,000 feet above the surface.

All instrument readings obtained by aerial and ground monitors off the Nevada Test Site were essentially background. However, filters and charcoal cartridges on high volume air samplers collected small amounts of short-lived fission products at four of the routine air sampling stations. The highest level of short-lived activity found at any station was 20 pc/m³ of iodine–133 (extrapolated to mid-point of collection) on a filter at Death Valley Junction, California, for a collection period 0930–1550 December 12. (Iodine–131 was not detected.) A charcoal cartridge on an air sampler at the same station collected 15 pc/m³ of iodine–133 for the period 0930–1705 December 12. (Iodine–131 was not detected.)

No fresh fission products (such as iodine–131) were detected in any milk samples.

Pike

The Pike event was a low yield, underground nuclear test detonated March 13, 1964. Shortly after the detonation, radioactivity started escaping from the ground. The winds carried the activity in a southeasterly direction.

The activity was tracked by aircraft southeastward past Las Vegas. A second aircraft, equipped with extremely sensitive instruments aboard, tracked the remaining radioactivity to southern Nevada, Arizona and to a portion of California, adjacent to Arizona. Some spotty patches of activity just above background were detected in southern Arizona and California. Table 3 gives the highest recorded air filter measurements for populated areas.

TABLE 3.—AIR FILTERS SHOWING HIGHEST ACTIVITIES RELATED TO PIKE EVENT

Station	Collection Period	Gross Beta (pc/m³)	Charcoal Cartridge		
			I-131	I-133 (pc/m³)	I-135
Cactus Springs	0840/13th to 1120/13th	50,000	[a,b] ND	[b] 700	510
Cactus Springs	1128/13th to 1503/13th	9,000	ND	98	96
Cactus Springs	1505/13th to 1141/13th	23	Trace	4.5	Trace
Indian Springs	0852/13th to 1102/13th	35,000	ND	190	160
Indian Springs	1106/13th to 1530/13th	15,000	ND	123	92
Indian Springs	1530/13th to 1154/14th	42	ND	2.9	ND
Las Vegas	1140/13th to 1445/13th	14,000	ND	60	100
Las Vegas	1450/13th to 1845/13th	680	ND	10	ND
Las Vegas	1850/13th to 2348/13th	59	ND	0.8	ND

[a] ND indicates not detectable.

[b] In addition, the glass fiber filter showed the following values (in picocuries per cubic meter) I-133, 1,000; I-133, 35,000.

The highest potential out-of-door external gamma radiation exposure at populated areas was about 18 milliroentgens at Cactus Springs, Nevada. The next highest was about six milliroentgens at Indian Springs, Nevada, and the third highest was less than one milliroentgen at Las Vegas, Nevada. These values may be compared with the 150–200 milliroentgen annual exposure in these areas from natural background radiation.

Although low levels of radioiodine appeared in some samples of milk from individual farms (table 4), none was found in commercially available milk at any location sampled. All of the cows in the Las Vegas area were on dry feed at this time of year. As an experiment, fresh cut green feed (called green chop) was supplied to six animals selected for experimental purposes at two Las Vegas farms. The highest iodine–131 levels in the milk from the experimental cows fed on green chop peaked at 420 picocuries per liter on March 21, 1964. The levels dropped to 70 picocuries per liter by March 31, 1964. The results of this experiment will be the subject of a separate report.

TABLE 4.—MILK SAMPLES FROM INDIVIDUAL FARMS (EXCEPT FOR THE LAS VEGAS FARMS) THAT SHOWED THE PRESENCE OF IODINE–131 AFTER THE PIKE EVENT [1]

Location	Type	Date Collected	I-131 (pc/liter)
Yuma, Arizona	Raw Milk	17 (AM)	30
Yuma, Arizona	Raw Milk	18 (AM)	50
Yuma, Arizona	Raw Milk	21	80
Yuma, Arizona	Raw Milk	22	60
Yuma, Arizona	Raw Milk	24	40
Yuma, Arizona	Raw Milk	25 (AM)	40
Yuma, Arizona	Raw Milk	26	30
Bard, California	Raw Milk	26 (AM)	50
Blythe, California	Raw Milk	21 (PM)	30
Winterhaven, California	Raw Milk	25 (AM)	40
Winterhaven, California	Raw Milk	26	50

[1] Milk not commercially available.

REPORTED NUCLEAR DETONATIONS, JULY 1964

Two low-yield underground nuclear tests at the Nevada Test Site during July 1964 were announced by the Atomic Energy Commission. These tests conducted on July 16, and 17th were assigned arbitrary *Radiological Health Data* reference numbers 161 and 162, respectively. The former was a United States nuclear test; the latter was a test of a British nuclear device conducted under the Agreement for Cooperation on the Uses of Atomic Energy for Mutual Defense Purposes, which has been in effect between the two countries since August 4, 1958.

RADIOLOGICAL HEALTH DATA

VOLUME V, NUMBER 9
SEPTEMBER 1964

TABLE OF CONTENTS

Page

SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation 411
1. Radiation Surveillance Network, May 1964, *PHS* 411
2. Canadian Air Monitoring Program, May 1964 415
3. Mexican Air Monitoring Program, May 1964 417
4. Pan American Air Sampling Program, May 1964, *PAHO* and *PHS* 418
5. Gross Beta Activity in Air, North America, May 1964 418

SECTION II.—MILK AND FOOD

Milk Surveillance 421
1. Pasteurized Milk Network, May 1964, *PHS* .. 421
2. California Milk Network, January—March 1964 425
3. Connecticut Milk Network, January—December 1963 427
4. Indiana Milk Network, May 1964 427
5. New York Milk Network, March 1964 428
6. Canadian Milk Network, May 1964 429
Moving Annual Average Radionuclide Concentrations in Pasteurized Milk June 1963—May 1964, *PHS* 431
Strontium-90 in Tri-City Diets, November 1963—January 1964, *AEC* 433
Cesium-137 in Tri-City Diets, October—December 1962, *Joseph Rivera* and *John J. Kelly* .. 434

SECTION III.—WATER

Radioactivity in Surface Waters of the United States, March 1964, *PHS* 437
Radioactivity in California Surface Water, July—December 1963 440
North Carolina Surface, Ground, and Cistern Water, November 1961—December 1963 442

SECTION IV.—OTHER DATA

Summary of State Radiological Environmental Surveillance Activities, *Carnick A. Markarian*, *George W. Williams*, and *Guntis Ozolins* 447
Environmental Levels of Radioactivity at Atomic Energy Commission Installations 451
1. Atomics International, Calendar Year 1963 .. 451
2. National Reactor Testing Station, Calendar Year 1963 453
3. Pinellas Peninsula Plant, Calendar Year 1963 455
Reported Nuclear Detonations, August 1964 456

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

112

Section I—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess human radiation exposure from fallout, it is widely used as the basis of alerting systems for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form and are also shown by beta concentration isograms in figure 5.

1. Radiation Surveillance Network
May 1964

Division of Radiological Health,
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health which gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to allow for decay of naturally-occurring radon daughters. The network station operators regularly report their field estimates to the Radiation Surveillance Center, Division of Radiological Health, Washington, D. C. These field estimates are reported elsewhere on a monthly basis (*1*). When unusually high air levels are reported, appropriate Federal and State officials are notified.

Air

Airborne particulates are collected continuously on a carbon-loaded cellulose dust filter 4 inches in diameter. A volume of about 1800 cubic meters of air is drawn through the filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, and the gross beta activity measured using a thin-window, gas-flow proportional counter, calibrated with a Sr^{90}–Y^{90} standard.

113

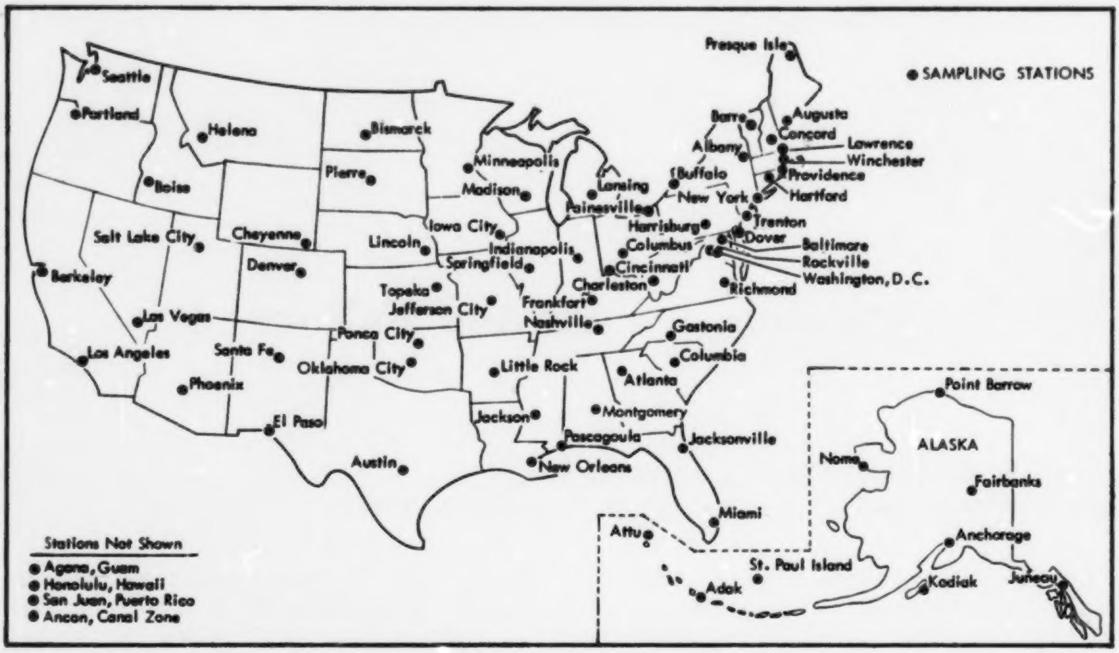
SAMPLING STATIONS
Seattle
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Lansing
Painesville
Buffalo
Presque Isle
Barre
Augusta
Concord
Albany
Lawrence
Winchester
Providence
Hartford
New York
Trenton
Harrisburg
Dover
Baltimore
Rockville
Washington, D.C.
Columbus
Cincinnati
Richmond
Charleston
Salt Lake City
Cheyenne
Iowa City
Lincoln
Indianapolis
Springfield
Denver
Berkeley
Topeka
Jefferson City
Frankfort
Nashville
Las Vegas
Gastonia
Ponca City
Los Angeles
Santa Fe
Oklahoma City
Little Rock
Columbia
Phoenix
Atlanta
El Paso
Jackson
Montgomery
Pascagoula
Jacksonville
Austin
New Orleans
Miami
Attu
St. Paul Island
Adak
ALASKA
Point Barrow
Nome
Fairbanks
Anchorage
Kodiak
Juneau
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS

Each filter is counted at least 3 days after the end of the sampling period and again 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. By using the two counts and the Way-Wigner formula (*2*), the age of fission products is estimated, and the activity extrapolated to the time of collection.[1] The daily concentrations and estimated age of selected samples are reported by the PHS in a monthly RSN report (*1*).

The network's highest activity during May was observed on the Salt Lake City, Utah, May 19 sample. The twenty samples with the highest activities during May are listed in table 1, together with their gross beta concentrations.

The May 1964 average gross beta concentration in air for each station is given in table 2. The network average for May (1.94 pc/m^3) showed an increase over both the March and April averages, 1.56 and 1.60 pc/m^3, respectively. The twenty highest samples in May ranged from 5.15 to 8.44 pc/m^3. In April the twenty highest samples ranged from 5.06 to 7.76 pc/m^3.

Time profiles of gross beta activity in air for eight RSN stations are shown in figure 2.

TABLE 1.—GROSS BETA ACTIVITY OF THE TWENTY INDIVIDUAL RSN AIR FILTERS HAVING HIGHEST ACTIVITIES DURING MAY 1964

Station		Date	Concentration (pc/m^3)
Colo:	Denver	May 4	6.09
		6	8.00
		8	5.55
Idaho:	Boise	19	5.45
		24	5.45
		26	6.77
		27	5.52
Miss:	Jackson	1	5.20
Nev:	Las Vegas	18	7.71
		19	6.91
		21	5.15
N. Y.:	Buffalo	27	5.97
Ohio:	Painesville	19	5.16
Tenn:	Nashville	1	5.84
Utah:	Salt Lake City	19	8.44
Vt:	Barre	4	6.45
		5	5.69
Wyo:	Cheyenne	4	6.87
		5	6.40
		6	5.89

---

[1] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value and cannot be used for estimating date of formation.

TABLE 2.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, MAY 1964

Station location		Air surveillance					Precipitation measurements	
		Number of samples	Gross beta activity (pc/m³)			Last profile in *RHD*	Average concentration (pc/liter)[b]	Total deposition[b] (nc/m²)
			Maximum	Minimum	Average[a]			
Alabama:	Montgomery	20	3.91	0.64	2.01	Aug 64	590	21.7
Alaska:	Adak	29	4.01	<0.10	1.40	Nov 63		
	Anchorage	31	2.31	0.23	0.94	Jul 64	770	15.9
	Attu	29	4.40	<0.10	1.25	Dec 63		
	Fairbanks	22	1.73	0.22	0.92	Aug 64	390	3.8
	Juneau	13	1.84	<0.10	0.86	Sep 64	380	64.1
	Kodiak	17	2.10	<0.10	0.75	Oct 63	[b]	
	Nome	12	1.50	0.14	0.72	Feb 64		
	Point Barrow	26	1.72	<0.10	0.70	Jan 64		
	St. Paul Island	18	2.57	0.47	1.29	Mar 64		
Ariz:	Phoenix	29	4.76	1.30	2.62	Sep 64		
Ark:	Little Rock	30	4.71	0.62	2.11	Sep 64	260	8.2
Calif:	Berkeley	20	1.73	0.42	0.92	Oct 63		
	Los Angeles	21	1.85	0.85	1.38	Feb 64		
Canal Zone:	Ancon	16	0.99	<0.10	0.48	Apr 64		
Colo:	Denver	27	8.00	1.25	2.87	Nov 63	270	19.8
Conn:	Hartford	31	3.74	0.31	1.91	Oct 63	610	20.8
Del:	Dover	18	4.96	0.56	2.62	Aug 64		
D. C:	Washington	29	4.79	0.14	2.69	Aug 64	930	35.4
Fla:	Jacksonville	29	3.87	0.77	2.48	Sep 64	430	17.3
	Miami	29	3.39	0.53	1.74	Feb 64	260	34.2
Ga:	Atlanta	12	2.74	0.20	1.55	Jul 64	290	18.4
Guam:	Agana	31	1.10	<0.10	0.38	Apr 64		
Hawaii:	Honolulu	31	1.83	0.34	0.97	Feb 64	360	3.6
Idaho:	Boise	30	6.77	0.79	2.62	Dec 63	570	29.8
Ill:	Springfield	28	4.16	0.48	1.94	Mar 64	1,100	22.5
Ind:	Indianapolis	31	3.79	0.85	2.20	Jul 64	1,000	35.9
Iowa:	Iowa City	27	4.76	0.25	2.12	Jan 64	520	27.3
Kans:	Topeka	21	4.64	0.45	1.68	Jul 64	700	28.1
Ky:	Frankfort	31	4.26	0.73	2.45	Feb 64	760	24.1
La:	New Orleans	31	2.23	0.50	1.30	Mar 64	980	27.1
Maine:	Augusta	31	4.19	0.14	2.22	Mar 64	520	24.9
	Presque Isle	26	4.38	<0.10	1.60	Nov 63		
Md:	Baltimore	20	4.31	0.17	2.23	Nov 63	650	6.5
	Rockville	7	3.69	1.62	2.33	Mar 64		
Mass:	Lawrence	31	4.88	0.42	2.16	Aug 64	1,200	34.9
	Winchester	29	3.40	0.83	2.05	Apr 64	780	19.4
Mich:	Lansing	31	4.39	0.98	2.63	Feb 64	670	50.3
Minn:	Minneapolis	29	4.66	0.12	1.70	Mar 64	860	73.1
Miss:	Jackson	27	5.20	0.69	2.66	Apr 64	370	9.5
	Pascagoula	9	2.78	0.93	1.76	Dec 63		
Mo:	Jefferson City	31	3.01	0.57	1.67	Jul 64	280	22.9
Mont:	Helena	31	5.12	<0.10	1.79	Nov 63	470	24
Nebr:	Lincoln	4	3.03	1.03	2.04	Apr 64		
Nev:	Las Vegas	26	7.71	1.49	3.82	Aug 64		
N. H:	Concord	20	5.12	0.82	2.67	Feb 64	380	43.9
N. J:	Trenton	31	3.98	0.31	2.14	Apr 64	1,500	2.5
N. Mex:	Santa Fe	23	3.95	0.48	1.62	Dec 63	1,400	26.9
N. Y:	Albany	20	2.81	0.73	1.76	Jul 64	470	11.2
	Buffalo	6	5.97	0.89	3.24	Nov 63		
	New York	19	4.80	0.21	2.28	Dec 63		
N. C:	Gastonia	31	5.11	0.99	2.70	Jan 64	520	4.9
N. Dak:	Bismarck	31	4.33	0.26	2.13	Feb 64	1,100	30.1
Ohio:	Cincinnati	20	4.64	0.73	2.42	Aug 64		
	Columbus	31	4.39	0.59	2.31	Apr 64	770	68.2
	Painesville	31	5.16	0.42	3.08	Oct 63	980	85.8
Okla:	Oklahoma	24	3.52	0.42	1.88	Apr 64	350	16.5
	Ponca City	30	3.06	0.37	1.12	Oct 63	270	32.2
Ore:	Portland	30	4.79	0.22	2.54	Oct 63	350	9.1
Pa:	Harrisburg	31	2.67	<0.10	1.30	Jul 64	800	15.9
P. R:	San Juan	30	2.23	0.35	1.14	Mar 64	500	1.4
R. I:	Providence	26	4.25	0.52	2.48	Jan 64	1,200	15.4
S. C:	Columbia	30	3.85	0.44	2.19	Dec 63	1,100	62
S. Dak:	Pierre	31	4.47	0.31	2.15	Sep 64	400	23
Tenn:	Nashville	29	5.84	0.83	2.65	Jan 64	790	70.8
Tex:	Austin	29	4.17	0.32	1.42	Aug 64	250	12
	El Paso	30	4.95	0.59	2.00	Jan 64	320	2.8
Utah:	Salt Lake City	31	8.44	<0.10	2.30	Aug 63	600	51.5
Vt:	Barre	29	6.45	0.19	3.07	Sep 64	620	36.2
Va:	Richmond	31	4.17	0.17	1.96	Sep 64	710	23.2
Wash:	Seattle	31	2.05	0.15	1.11	Jul 64	1,400	30.7
W. Va:	Charleston	31	4.31	0.64	2.55	Dec 63	1,100	21.5
Wisc:	Madison	29	4.65	0.32	2.43	Sep 64	8.0	97.2
Wyo:	Cheyenne	31	6.87	0.75	2.59	Aug 64	1,100	20.3
Network summary		1817	8.44	<0.10	1.94		603	28.5

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[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed before the average.

[b] Blank spaces indicate precipitation not sampled.

115

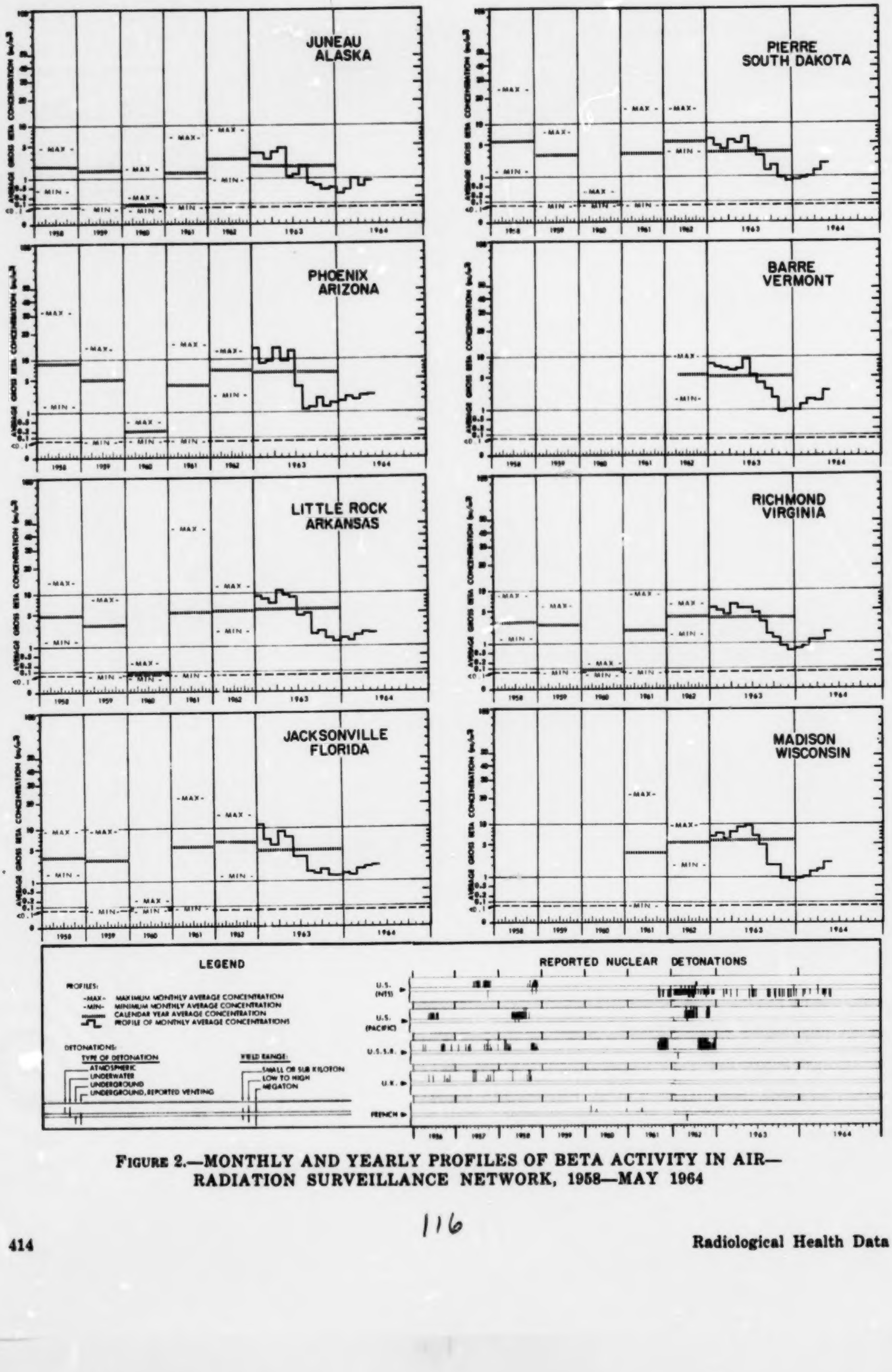

Figure 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR—RADIATION SURVEILLANCE NETWORK, 1958—MAY 1964

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D=\frac{CP}{1000}$$

where D is the deposition in nc/m^2, C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, $\overline{C}$, is determined by:

$$\overline{C}=\frac{\Sigma D}{\Sigma P}\times 1000$$

The May 1964 average concentrations and total depositions are given in table 2.

2. Canadian Air Monitoring Program[2]
May 1964

Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas-flow, Geiger-Mueller counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for May 1964 are given in table 3 and presented in conjunction with U. S. and Mexican data by an isogram map (figure 5).

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

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[2] Data from *Radiation Protection Programs 6*:11-24, Radiation Protection Division, Canadian Department of National Health and Welfare, Ottawa, Canada (May 1964).

117

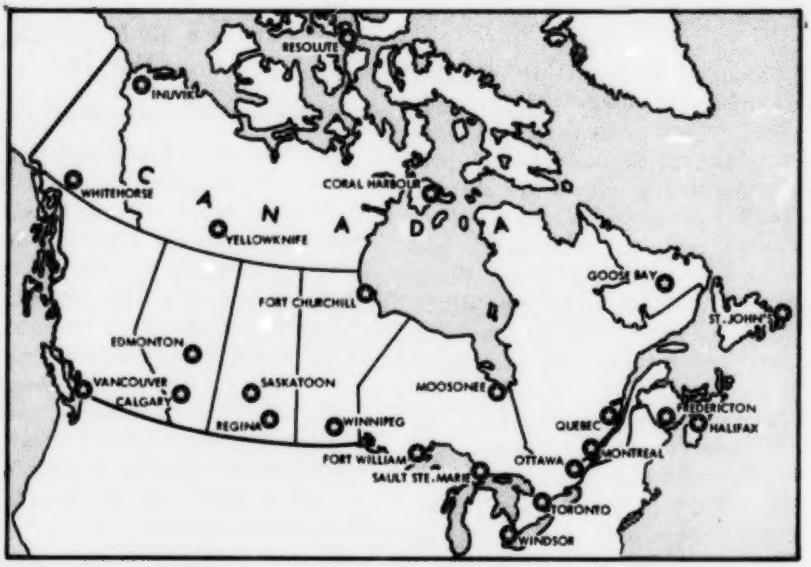
RESOLUTE
INUVIK
WHITEHORSE
C A N A D A
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
MONTREAL
OTTAWA
FORT WILLIAM
SAULT STE. MARIE
TORONTO
WINDSOR

FIGURE 3.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450°C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}–Y^{90} source. Gross beta activities for May 1964 samples are given in table 3. Radionuclide analyses appear quarterly.

TABLE 3.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, CANADA, MAY 1964

Station	Air surveillance				Precipitation data	
	Number of samples	Gross beta activity (pc/m³)			Average concentration (pc/liter)	Total deposition (nc/m²)
		Maximum	Minimum	Average		
Calgary	30	4.5	0.1	2.1	1,139	71.1
Coral Harbour	31	2.3	0.6	1.3		7.8
Edmonton	30	4.3	0.5	1.8	2,323	126.2
Ft. Churchill	29	3.7	0.1	1.2	2,192	36.7
Ft. William	31	3.3	0.3	1.7	1,190	167.1
Fredericton	31	3.6	0.1	1.5	798	39.9
Goose Bay	30	3.2	0.1	1.2	561	53.1
Halifax	25	4.0	0.1	1.9	749	44.7
Inuvik	31	2.6	0.1	1.3	730	5.6
Montreal	31	4.1	0.1	2.3	1,442	61.8
Moosonee	30	3.9	0.1	1.5	1,258	119.0
Ottawa	31	4.1	0.1	2.1	1,215	65.7
Quebec	31	4.0	0.1	1.8	827	66.9
Regina	31	7.0	0.4	2.3	1,322	47.3
Resolute	31	2.9	0.3	1.5	176	31.7
St. John's, Nfld	31	2.5	0.1	1.0	855	57.1
Saskatoon	30	4.9	0.5	2.4	1,455	63.1
Sault Ste. Marie	30	4.6	0.3	2.1	1,578	64.5
Toronto	31	4.1	0.1	2.2	1,565	66.7
Vancouver	31	2.6	0.4	1.5	2,055	90.7
Whitehorse	31	3.2	0.2	1.5	1,231	23.1
Windsor	31	3.7	0.2	2.2	874	38.1
Winnipeg	31	5.4	0.2	2.1	1,938	65.9
Yellowknife	31	2.4	0.3	1.2	2,098	24.5
Network summary		3.8	0.2	1.7	1,286	59.9

3. Mexican Air Monitoring Program
May 1964

National Commission of Nuclear Energy

As part of its Radiological Protection Program, (RPP) the *Comision Nacional de Energía Nuclear* (CNEN) Mexico City, established the Radiation Surveillance Network of Mexico to provide a means for determining increased levels of radioactivity in air and precipitation.

The network has been gradually expanded to 17 stations (see figure 4). Twelve of the 17 stations are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí and Ensenada; staff members of the RPP operate the station at Mexico City while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Instituto de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week, at the rate of approximately 1,200 cubic meters per day, through a high-efficiency glass fiber filter, 6" x 8", using high volume samplers. After each 24-hour period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios Sobre Contaminación Radiactiva", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughters' natural radioactivity. Data are not extrapolated to time of collection.

The maximum, minimum and average fission product beta concentrations in surface air during May 1964 are presented in table 4.

TABLE 4.—GROSS BETA ACTIVITY IN SURFACE AIR, MEXICO, MAY 1964

[Concentrations in pc/m³]

Station	Number of Samples	Maximum	Minimum	Average
Acapulco	20	4.6	0.7	1.4
Ciudad Juárez	21	3.1	0.3	1.2
Chihuahua	19	4.5	0.4	1.7
Ensenada	12	2.4	1.0	1.9
Guadalajara	16	1.7	0.3	1.1
Guaymas	4	2.7	1.2	[a]—
La Paz	18	4.7	1.2	2.7
Matamoros	7	0.8	0.2	0.5
Mazatlán	23	6.7	1.6	3.3
Mérida	7	1.2	0.4	0.9
México, D.F.	23	1.6	0.2	0.6
Nuevo Laredo	10	1.8	0.4	0.9
San Luis Potosí	7	1.2	0.3	0.6
Tampico	13	1.9	0.2	1.0
Torreón	25	2.8	0.3	1.3
Tuxtla Gutiérrez [b]				
Veracruz	20	3.5	0.3	1.1

[a] Average not calculated.

[b] Temporarily shut down.

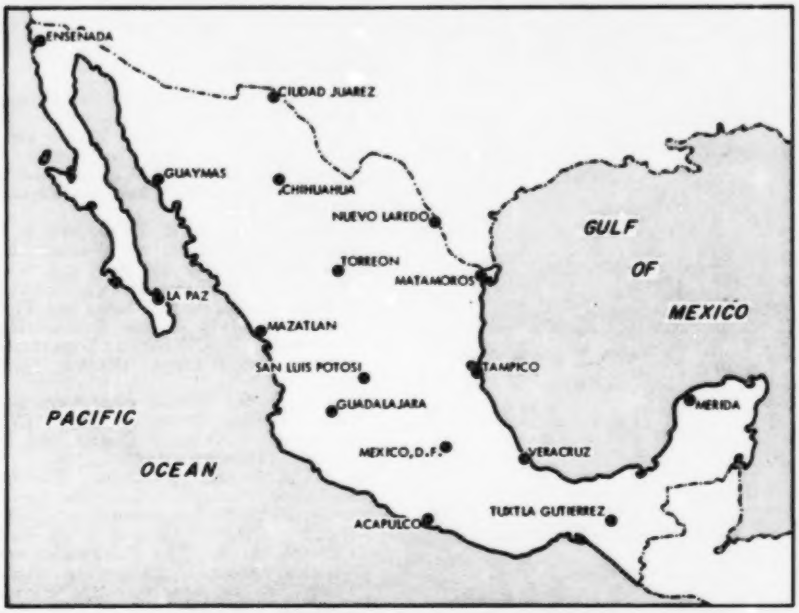

FIGURE 4.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

4. Pan American Air Sampling Program May 1964

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by four countries in the Americas under the auspices of a collaborative program developed by the Pan American Health Organization (PAHO) and the Public Health Service (PHS) for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The four air sampling stations included in the program are operated by the technical staff of the Ministry of Health in each country. The station in Kingston, Jamaica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupational Health; and in Santiago, Chile, by the Occupational Health Service. The Kingston station began operation in March 1964; the other three were started near the end of 1962.

The May 1964 air monitoring results from the four participating countries are given in table 5. The Caracas and Jamaica stations, included in figure 5 with the May averages adjusted by the RSN intercalibration factor,[3] were used in positioning the beta concentration isograms.

Table 5.—GROSS BETA ACTIVITY IN AIR, MAY 1964

[Concentrations in pc/m³]

Sampling stations	No. of samples	Maximum	Minimum	Average [a]
Kingston, Jamaica	27	1.26	0.42	0.86
Caracas, Venezuela	21	1.08	<0.10	0.66
Lima, Peru	18	0.12	<0.10	<0.10
Santiago, Chile	22	0.16	<0.10	<0.10

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

5. Gross Beta Activity in Air, North America May 1964

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America. The data from the Radiation Surveillance Network and the Canadian air network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*8*).

With the formation of the Mexican air monitoring program, new intercalibration ratios were determined, this time including the Canadian network, Radiation Surveillance Network, National Air Sampling Network, the HASL 80th Meridian Network, and the Mexican Network (*9*). The new intercalibration factors reflect some changes in standardization in both the RSN and the Canadian air network, effective September 1963.

Figure 5 shows the May 1964 activity in air throughout North America based on the data from the Canadian Air Monitoring Program, the Radiation Surveillance Network and Mexican air monitoring program. An intercalibration factor of 1.28 was applied to the RSN data and the Mexican data were multiplied by 0.81 in order to adjust them to Canadian data.

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(*2*) Way, K., and E. P. Wigner: The Rate of Decay of Fission Products, *Physical Review, 73:* 1318–30 (June 1, 1948).

(*3*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1959 on the Radioactive Fallout Study Program, CNHW–RP–3*, Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*4*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4*, Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*5*) Mar, P. G.: *Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5*, Department of National Health and Welfare, Ottawa, Canada (December 1962).

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(*7*) *Booth, A. H.: The Calculation of Maximum Permissible Levels of Fallout in Air and Water and Their Use in Assessing the Significance of 1961 Levels in Canada, RPD–21*, Department of National Health and Welfare, Ottawa, Canada (August 1962).

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[3] The RSN factor is 1.28.

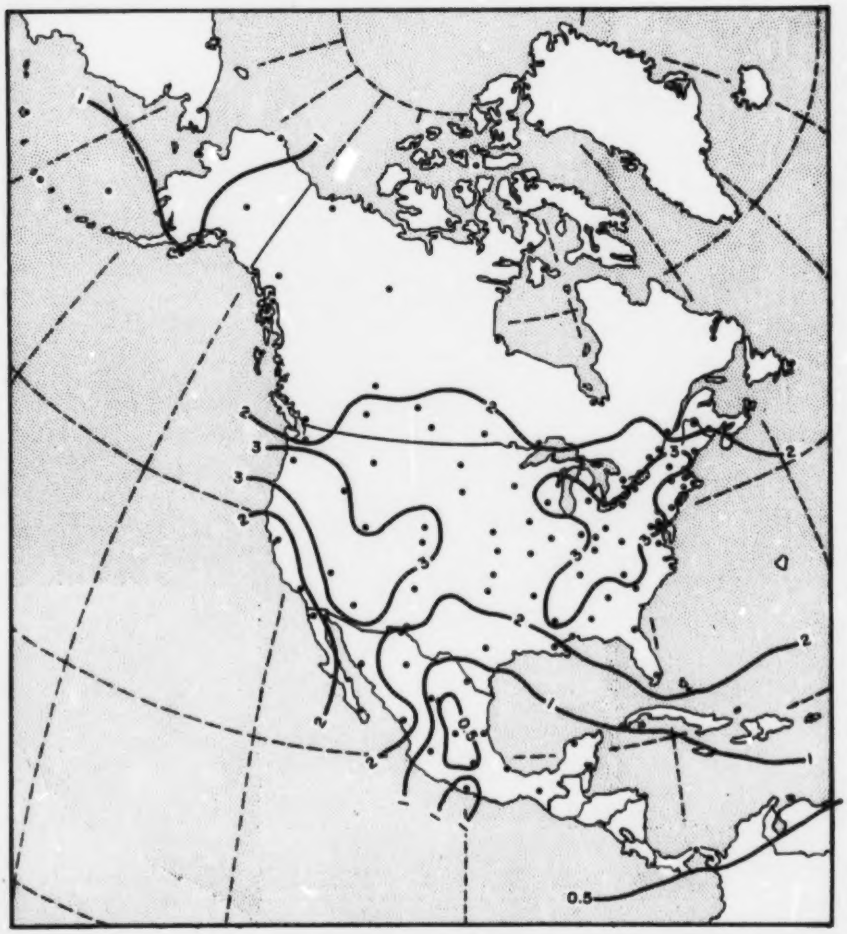

FIGURE 5.—ISOGRAMS OF AVERAGE GROSS BETA CONCENTRATIONS IN AIR, NORTH AMERICA, MAY 1964

(8) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850*, Naval Research Laboratory, Washington, D. C. 20390 (November 13, 1962); abstracted in *Radiological Health Data*, December 1962.

(9) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: *Intercalibration of the Major North American Networks Employed in Monitoring Airborne Fission Products, NRL Report 6025*, Naval Research Laboratory, Washington, D. C. 20390 (December 1963); summarized in *Radiological Health Data*, Jan. 1964.

Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, May 1964

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Sampling Procedure

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. Composites of the samples are preserved with formaldehyde and are sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL) for analysis. Gamma analyses for iodine–131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after collection; publication in *RHD* follows 3 to 4 months after sample collection.

The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Analytical Procedures

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma

122

scintillation spectroscopy.[1] After the weekly samples are gamma scanned, samples from two consecutive weeks are composited and analyzed radiochemically for strontium-89 and strontium-90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation is dependent upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclide and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. The ±2 standard deviations (2σ) about the measured concentration correspond to a 95 percent certainty that the true concentration is within this range. The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error [a] (pc/liter)	Estimated concentration (pc/liter)	Error [a] (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10%
Barium-140	0 to 100	±10	100 or greater	±10%
Cesium-137	0 to 100	±10	100 or greater	±10%
Strontium-89	0 to 50	±5	50 or greater	±10%
Strontium-90	0 to 20	±2	20 or greater	±10%

[a] Two standard deviations (2σ).

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium-40 concentrations[2] determined from the gamma spectrum.

Data Presentation

Table 2 presents summaries of the analyses for May 1964 (April 26-May 30, 1964). Although not shown in table 2, the iodine-131 and barium-140 monthly average concentrations in milk were less than 10 pc/liter. Radionuclide values reported by a laboratory as being below the minimum detectable concentration have been averaged by using one-half the minimum detectable value. The averaging procedure was modified for iodine-131 and barium-140 in October 1963, when nondetectable concentrations of these radionuclides were considered zero. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium-90 and cesium-137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modifications of the isograms are made according to available information on milksheds.

In order to develop the distribution of the network's stations *versus* radionuclide concentrations in milk, table 3 has been prepared using monthly averages shown in table 2.

Continuing the practice followed in previous issues of *RHD*, the average monthly strontium-90 concentrations in pasteurized milk from 16 selected cities in the sampling program are presented in figure 3. Each graph shows the strontium-90 concentrations in milk from one city in each of the four U. S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a year. The last column in table 2 shows the most recent issue in which a graph of the strontium-90 concentration was given for each station. A tabulation of the network monthly maximum, minimum, and average radionuclide concentrations in milk was given for March 1960-March 1964 in the July 1964 issue of *RHD* (*2*).

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

[2] The conversion factor is 1.18 x 10^{-3} g K/pc K^{40}.

TABLE 2.—STABLE ELEMENT AND RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, MAY 1964 [a]

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (g/liter)		Potassium (g/liter)		Strontium-89		Strontium-90		Cesium-137		Last Sr^{90} graph in *RHD* (1964)
		First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	
Ala:	Montgomery	1.19	1.15	1.5	1.5	<5	<5	24	30	100	100	June
Alaska:	Palmer	1.16	1.23	1.5	1.4	10	5	23	28	160	155	July
Ariz:	Phoenix	1.18	1.17	1.5	1.5	<5	<5	4	5	25	30	Sept
Ark:	Little Rock	1.18	1.14	1.5	1.5	<5	<5	43	69	165	190	July
Calif:	Sacramento	1.25	1.25	1.6	1.5	<5	<5	11	8	65	40	Aug
	San Francisco	1.23	1.21	1.5	1.5	<5	<5	13	11	75	50	June
Canal Zone:	Cristobal	1.13	1.10	1.6	1.6	<5	<5	6	6	50	55	July
Colo:	Denver	1.23	1.19	1.6	1.4	<5	<5	19	20	90	80	Aug
Conn:	Hartford	1.15	1.17	1.6	1.5	<5	<5	23	23	185	155	Aug
Del:	Wilmington	1.21	1.21	1.6	1.5	<5	<5	21	34	150	155	Sept
D. C:	Washington	1.17	1.09	1.6	1.5	<5	<5	18	25	105	100	June
Fla:	Tampa	1.21	1.13	1.5	1.5	<5	<5	15	15	200	275	Sept
Ga:	Atlanta	1.21	1.13	1.6	1.5	<5	<5	35	41	160	190	June
Hawaii:	Honolulu	1.18	1.15	1.6	1.6	<5	<5	11	10	80	85	July
Idaho:	Idaho Falls	1.19	1.20	1.6	1.5	5	10	27	30	220	195	Sept
Ill:	Chicago	1.18	1.12	1.6	1.5	<5	<5	21	17	145	130	June
Ind:	Indianapolis	1.22	1.21	1.6	1.5	<5	<5	22	30	120	105	Aug
Iowa:	Des Moines	1.22	1.20	1.5	1.5	<5	5	27	34	110	100	Sept
Kans:	Wichita	1.21	1.21	1.5	1.5	10	5	23	28	80	80	July
Ky:	Louisville	1.18	1.11	1.6	1.5	<5	<5	32	37	125	90	Sept
La:	New Orleans	1.22	1.18	1.5	1.5	<5	<5	54	59	165	195	July
Maine:	Portland	1.20	1.19	1.6	1.5	<5	<5	31	34	220	225	Sept
Md:	Baltimore	1.17	1.12	1.5	1.5	<5	<5	20	30	115	130	Sept
Mass:	Boston	1.20	1.19	1.6	1.6	<5	<5	32	39	265	240	June
Mich:	Detroit	1.19	1.16	1.6	1.5	<5	<5	19	22	135	130	Aug
	Grand Rapids	1.21	1.23	1.5	1.5	<5	<5	22	24	145	140	Sept
Minn:	Minneapolis	1.18	1.22	1.6	1.5	10	10	35	39	190	165	June
Miss:	Jackson	1.26	1.23	1.5	1.5	5	<5	41	54	125	130	Aug
Mo:	Kansas City	1.22	1.19	1.5	1.4	5	10	28	35	100	95	Aug
	St. Louis	1.20	1.19	1.5	1.5	5	<5	23	30	100	90	July
Mont:	Helena	1.22	1.18	1.5	1.6	10	<5	31	34	235	205	July
Nebr:	Omaha	1.21	1.28	1.5	1.5	5	5	25	32	105	105	Sept
Nev:	Las Vegas	1.24	1.19	1.6	1.5	<5	<5	15	13	95	85	June
N. H:	Manchester	1.22	1.18	1.7	1.5	<5	<5	32	34	260	250	Sept
N. J:	Trenton	1.19	1.17	1.6	1.5	5	<5	18	25	140	140	Aug
N. Mex:	Albuquerque	1.19	1.18	1.5	1.5	<5	<5	12	12	60	55	July
N. Y:	Buffalo	1.16	1.17	1.6	1.5	<5	<5	20	23	170	155	Aug
	New York	1.16	1.14	1.6	1.5	<5	<5	25	28	190	175	June
	Syracuse	1.18	1.16	1.6	1.6	<5	<5	22	24	170	165	July
N. C:	Charlotte	1.22	1.17	1.5	1.5	<5	<5	31	46	115	155	July
N. Dak:	Minot	1.21	1.18	1.5	1.5	15	20	58	77	160	175	Sept
Ohio:	Cincinnati	1.21	1.19	1.6	1.5	<5	<5	24	30	125	95	Aug
	Cleveland	1.21	1.18	1.6	1.5	<5	<5	22	24	135	125	July
Okla:	Oklahoma City	1.18	1.13	1.6	1.6	<5	<5	25	29	90	75	June
Ore:	Portland	1.24	1.26	1.5	1.4	5	10	27	43	155	160	Aug
Pa:	Philadelphia	1.21	1.17	1.6	1.6	<5	<5	20	28	145	150	July
	Pittsburgh	1.19	1.19	1.6	1.5	<5	<5	28	34	170	175	July
P. R:	San Juan	1.16	1.09	1.6	1.5	<5	<5	12	14	70	90	July
R. I:	Providence	1.18	1.18	1.6	1.5	<5	<5	25	27	185	175	Sept
S. C:	Charleston	1.18	1.14	1.5	1.5	<5	<5	34	35	135	180	Aug
S. Dak:	Rapid City	1.19	1.24	1.5	1.5	10	10	38	52	175	155	June
Tenn:	Chattanooga	1.23	1.14	1.5	1.5	5	<5	28	52	145	145	June
	Memphis	1.21	1.14	1.5	1.5	<5	<5	32	43	90	100	Sept
Tex:	Austin	1.17	1.13	1.6	1.5	<5	<5	10	10	45	50	June
	Dallas	1.19	1.13	1.6	1.6	<5	<5	22	24	85	70	Aug
Utah:	Salt Lake City	1.21	1.26	1.5	1.6	5	20	27	39	215	185	July
Vt:	Burlington	1.18	1.17	1.6	1.5	<5	<5	26	30	210	195	Aug
Va:	Norfolk	1.18	1.11	1.6	1.5	<5	<5	20	31	105	125	Aug
Wash:	Seattle	1.21	1.22	1.5	1.5	10	10	21	44	120	170	June
	Spokane	1.24	1.24	1.6	1.5	5	15	33	29	145	155	Aug
W. Va:	Charleston	1.18	1.13	1.5	1.5	<5	<5	26	40	110	95	June
Wis:	Milwaukee	1.22	1.23	1.7	1.6	<5	<5	19	20	160	145	Sept
Wyo:	Laramie	1.18	1.22	1.5	1.4	10	<5	21	25	115	110	Sept
Network average		1.20	1.18	1.6	1.5	<5	<5	24.8	30.3	136	135	Nov. 63

[a] The monthly average iodine-131 and barium-140 concentration at each station was <10 pc/liter.

124

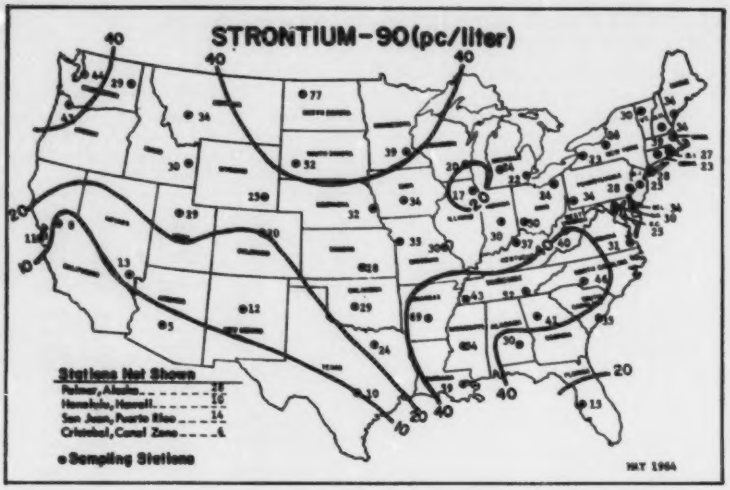
STRONTIUM-90(pc/liter)
40
40
40
20
10
20
10
20
40
40
20
Stations Not Shown
Palmer, Alaska 28
Honolulu, Hawaii 16
San Juan, Puerto Rico 14
Cristobal, Canal Zone 4
● Sampling Stations
MAY 1964

FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, MAY 1964

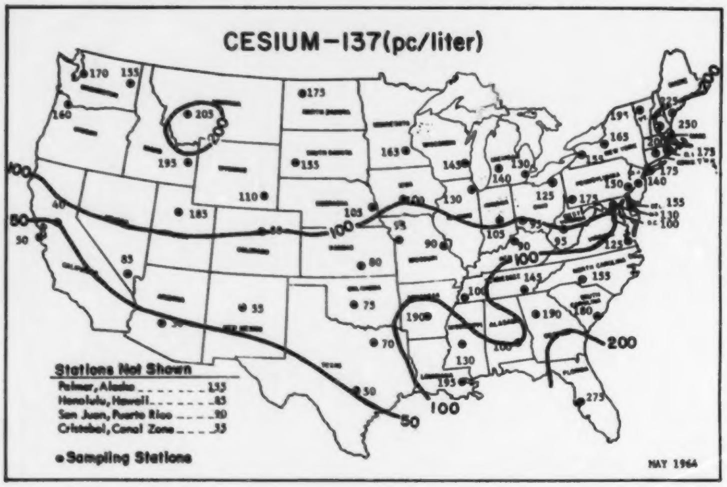
CESIUM-137(pc/liter)
100
50
100
100
200
100
50
Stations Not Shown
Palmer, Alaska 135
Honolulu, Hawaii 85
San Juan, Puerto Rico 90
Cristobal, Canal Zone 35
● Sampling Stations
MAY 1964

FIGURE 2.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK, MAY 1964

TABLE 3.—DISTRIBUTION OF SAMPLING STATIONS IN VARIOUS RANGES OF RADIONUCLIDE CONCENTRATIONS IN MILK, MAY 1964

Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
(pc/liter)	Number of stations	(pc/liter)	Number of stations	(pc/liter)	Number of stations	(pc/liter)	Number of stations	(pc/liter)	Number of stations
<5	50	<1-9	3	<10	63	<5-45	2	<10	63
5	4	10-19	8			50-95	16		
10	6	20-29	20			100-145	17		
15	1	30-39	20			150-195	23		
20	2	40-49	6			200-245	3		
		50-59	4			250-295	2		
		60-69	1						
		70-79	1						

125

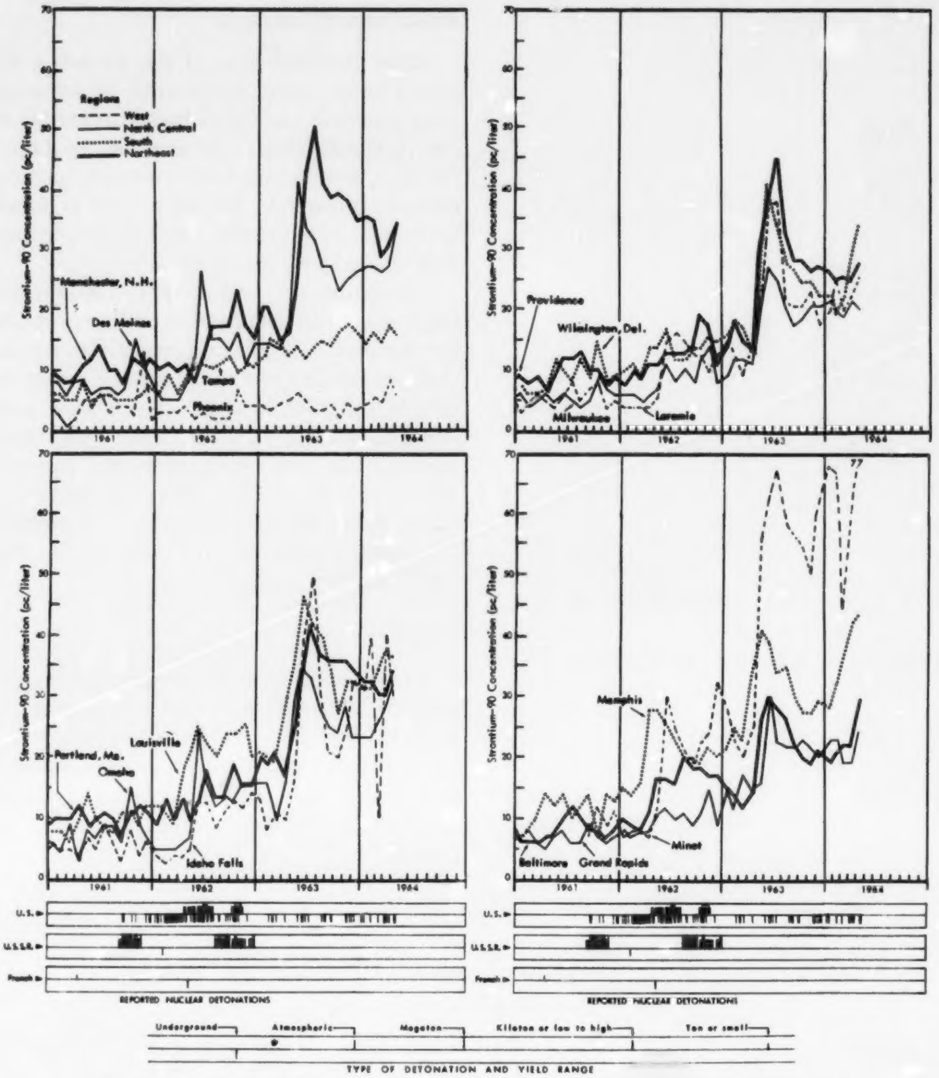

FIGURE 3.—STRONTIUM-90 IN PASTEURIZED MILK, 1961—MAY 1964

2. California Milk Network[3]
January-March 1964

State of California
Department of Public Health

Surveillance of specific radionuclides in milk is one phase of the California Department of Public Health program of radiation control. This milk monitoring function has been conducted at 8 milksheds since January 1960 by the Department's Bureau of Radiological Health, a constituent of the Division of Environmental Sanitation. Since the addition of the Del Norte and Mendocino milksheds to the program in March 1962, weekly or biweekly sampling of pasteurized milk has been conducted at 10 major milksheds (see figure 4). The original sampling locations were chosen by

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[3] Data from *Radiological Health News Vol. 3*, No. 3, Bureau of Radiological Health, State of California Department of Public Health, 2151 Berkeley Way, Berkeley 4, California.

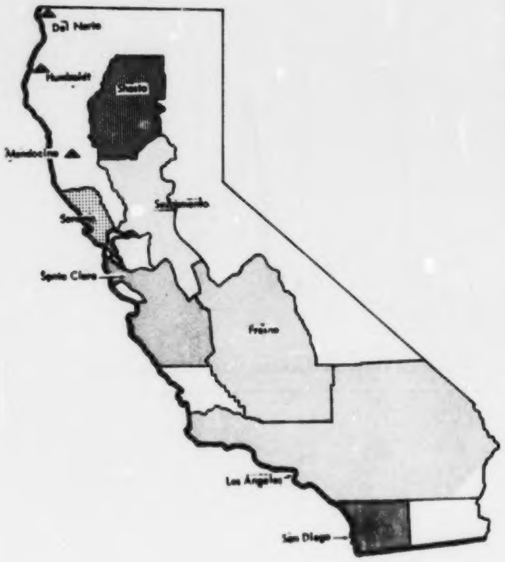


Figure 4.—CALIFORNIA MILKSHEDS

the State Department of Agriculture as being representative of milk consumed by a high percentage of the population of the State.

Analytical Procedures

After precipitation of the proteins with trichloroacetic acid, yttrium–90 is separated and beta counted, and total radiostrontium remaining in the filtrate is determined by beta counting in a low background counter, usually for a 60-minute period. Strontium–90 is determined from the yttrium–90 results; strontium–89 is determined by difference.

Potassium–40, iodine–131, cesium–137 and barium–140 in whole fluid milk are determined by gamma scintillation spectroscopy using a sodium-iodide crystal. A normal counting time of 100 minutes is used. The stable potassium content of milk (g/liter) may be estimated by multiplying the potassium–40 concentration (pc/liter) by 1.18 x 10^{-3}. A more complete description of the laboratory equipment and procedures has been published in the February 1963 issue of *RHD* (*3*).

Results

The monthly averages of the radionuclide and calcium data for milk for the period January-March 1964 are presented in table 4. Background information on the differences among the California milksheds was presented by Heslep and Cornish in the December 1963 issue of *RHD* (*4*).

Table 4.—RADIONUCLIDES IN CALIFORNIA MILK,[a] JANUARY–MARCH 1964

[Radioactivity concentrations in pc/liter]

Element and month	Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma	Average
Calcium (g/liter)											
January	1.33	1.21	1.15	1.16	1.19	1.22	1.18	1.20	1.18	1.21	1.2[illegible]
February	1.29	1.26	1.22	1.12	1.21	1.24	1.13	1.18	1.34	1.26	1.22
March	1.21	1.25	1.19	1.03	1.24	1.26	1.19	1.19	1.32	1.25	1.21
Potassium-40											
January	1200	1180	1180	1280	1340	1220	1370	1200	1290	1340	1260
February	1100	1200	1160	1230	1290	1230	1240	1280	1240	1240	1220
March	1150	1290	1140	1260	1280	1250	1250	1250	1180	1270	1230
Strontium-89											
January	37	2	15	4	4	2	3	2	7	2	8
February	52	[b] 0	16	[b] 0	3	4	[b] 0	2	3	2	8
March	21	[b] 0	9	1	4	1	[b] 0	[b] 0	5	2	4
Strontium-90											
January	113	5.7	24.5	5.9	7.0	7.0	4.8	8.4	11.3	9.9	19.8
February	67	8.1	19.0	6.1	8.7	7.8	7.5	4.8	13.0	13.2	15.6
March	96	7.3	31.1	6.7	11.4	10.0	6.0	5.9	15.0	16.4	20.6
Cesium-137											
January	190	52	76	54	34	47	25	52	84	60	67
February	201	43	66	44	34	52	26	41	60	54	62
March	195	36	78	47	42	56	31	40	92	54	67

[a] No significant amounts of iodine-131 or barium-lanthanum-140 in samples for this period were found.
[b] Value given is not at least twice the counting error at the 95 percent confidence level.

3. Connecticut Milk Network
January-December 1963

Connecticut State
Department of Health

The Connecticut State Department of Health began monitoring pasteurized fluid milk for strontium–89 and strontium–90 in April 1960. Beginning in May 1962 the Department's milk monitoring program was expanded to include the determination of gamma emitters in milk samples.

The sampling program is flexible, and as many as five areas of the State have been sampled. The frequency of sample collection has been as often as twice a week. Presently, a monthly sample representative of milk sold in the central area of the State is collected from a processing plant in Hartford. These samples are analyzed for iodine–131, strontium–89 and strontium–90.

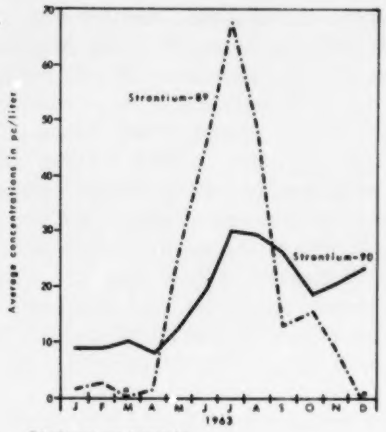
A low-background Geiger-Mueller counter with a thin end-window and gas-flow chamber is used for counting radiostrontium following chemical separation. Iodine–131 is determined by gamma scintillation spectroscopy using a 4" x 4" sodium iodide crystal and a 400-channel analyzer.

Table 5 gives the monthly average concentration of strontium–89, strontium–90, and iodine–131 in milk from Hartford, Connecticut during 1963. Radiostrontium data for 1963 are shown in figure 5. Connecticut milk monitoring data are not published on a regular monthly or quarterly basis in *RHD*. The previously published data for the period April 1960 through December 1962, appeared in the May 1963 issue (*5*).

TABLE 5.—RADIONUCLIDES IN HARTFORD, CONNECTICUT MILK, JANUARY-DECEMBER 1963

[Average concentrations in pc/liter]

Month 1963	Strontium-89	Strontium-90	Iodine-131
January	1	8.9	<10
February	2	8.9	<10
March	<1	11.0	<10
April	1	8.8	<10
May	27	12.6	<10
June	48	20.1	<10
July	67	30.0	<10
August	47	28.9	<10
September	13	26.6	<10
October	15	17.9	<10
November	8	21.3	<10
December	<1	22.9	<10



* Indicates not detectable

FIGURE 5.—RADIOSTRONTIUM IN HARTFORD, CONNECTICUT, MILK

4. Indiana Milk Network
May 1964

Bureau of Environmental Sanitation,
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analysis in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (figure 6).

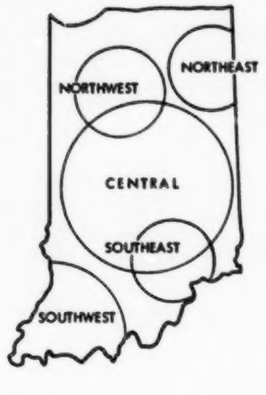


FIGURE 6.—INDIANA MILK SAMPLING LOCATIONS

The milk samples are routinely analyzed for iodine–131, cesium–137, barium–140, strontium–89 and strontium–90. Until August 1963, analyses for the gamma emitters iodine–131, cesium–137 and barium–140 were conducted on a weekly basis, except when iodine–131 exceeded 100 pc/liter, at which times the frequency of sampling was increased. Because of continued low concentrations of the short-lived gamma emitters, the sampling frequency was reduced in August 1963 to once per month for the northeast, southeast and southwest milksheds. Strontium–89 and strontium–90 analyses are performed monthly for each station.

An ion exchange analytical procedure (*6*) is employed for strontium–89 and strontium–90 analyses. Minimum detectable levels for strontium–89 and strontium–90 are about 5 and 1 pc/liter, respectively. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine–131, cesium–137 and barium–140. Analyses of counting statistics indicate that the lower limit of detectability for both iodine–131 and barium–140 is 5 pc/liter. Cesium–137 analyses are subject to a 6 percent error at the 100 pc/liter level. Additional factors such as drift of the analyzer and calibration factors will increase these limits to some extent.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 6.

TABLE 6.—RADIONUCLIDES IN INDIANA MILK, MAY 1964 [a]

[Radionuclide concentrations in pc/liter]

Sampling location	Calcium (g/liter)	Potassium-40	Strontium-90	Cesium-137
Northeast	1.16	1,300	22	105
Southeast	1.13	1,480	26	90
Central	1.22	1,450	30	95
Southwest	1.19	1,340	26	100
Northwest	1.15	1,440	28	115
State average	1.17	1,400	26	100

[a] The monthly average iodine-131, barium-140, and strontium-89 concentrations at each station were zero.

5. New York Milk Network
March 1964

Division of Environmental Health Services
State of New York Department of Health

Milk samples collected routinely from six cities—Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 7) are analyzed for their radionuclide content by the State of New York Department of Health. Pasteurized milk samples are collected daily and composited weekly for the determination of strontium–89, strontium–90, iodine–131, cesium–137 and barium–lanthanum–140 at all stations except Massena, where samples are composited bi-weekly, and at New York City where one daily milk sample representing the total milk supply for that day is obtained and analyzed once per week. Samples are obtained from processing plants except at Albany, where the daily sample is obtained from a marketing point. During periods when cows are no longer on stored feed, the sample from Albany is analyzed daily for iodine–131. In the event that any city reports iodine–131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken.

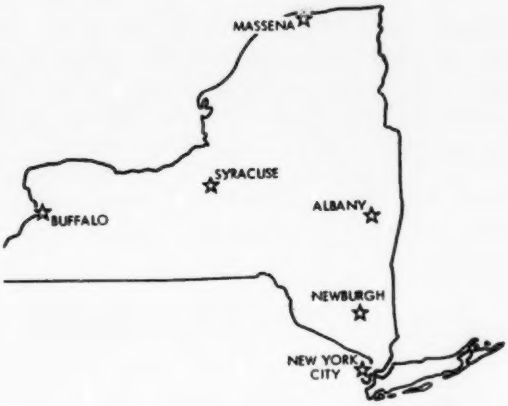


FIGURE 7.—NEW YORK MILK SAMPLING LOCATIONS

A matrix method (7) is used for the analysis of spectral data to determine the concentrations of gamma-emitting nuclides in milk. With this method, the individual nuclide contributions to the gamma spectrum are separated by solution of simultaneous equations describing the spectral interferences.

The analytical procedure for strontium-89 and strontium-90 is based on ion exchange methods. Cations (including radiostrontium) are eluted from the ion exchange resin with sodium chloride solution, strontium isotopes are gathered by means of sodium carbonate, isolated by means of ethylenediaminetetraacetic acid (EDTA), and radiostrontium is counted with a low background beta counter having an 0.8 mg/cm² window. The strontium-90 portion is differentially estimated by a second count 40 hours later to determine the rate of in-growth of its daughter product yttrium-90. The monthly average radionuclide concentrations in milk are shown in table 7.

TABLE 7.—RADIONUCLIDES IN NEW YORK MILK, MARCH 1964 [a]

[Average concentrations in pc/liter]

Sampling location	Strontium-89	Strontium-90	Cesium-137
Albany	<3	20	126
Buffalo	<3	16	105
Massena	10	27	226
Newburgh	6	19	126
New York City	3	25	142
Syracuse	4	18	122
Average	5	21	141

[a] The monthly average I^{131} and $Ba\text{-}La^{140}$ (in equilibrium) at each station was <20 pc/liter.

6. Canadian Milk Network[4]
May 1964

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium-90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963 liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and in addition it is possible to choose milk sampling locations (see figure 8) in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine-131, strontium-89, cesium-137 and strontium-90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies and are combined into weekly composites and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In

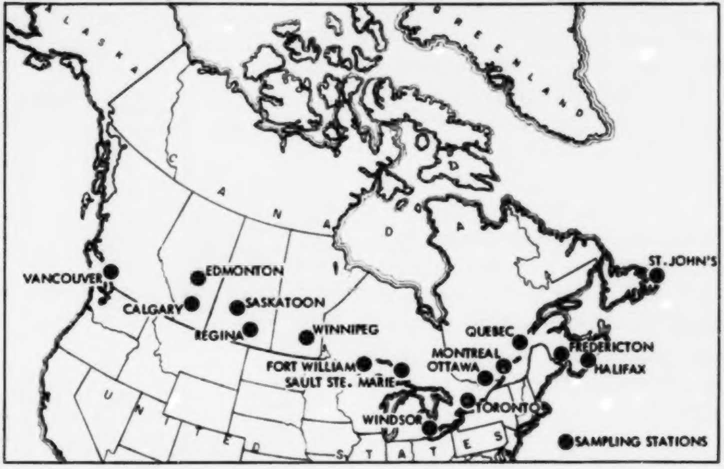


FIGURE 8.—CANADIAN MILK SAMPLING STATIONS

most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine-131. The results of the spot checks for iodine-131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium-90, cesium-137, and stable potassium and calcium.

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[4] Data from *Radiation Protection Programs, Vol. 2, No. 6:* 25-29, Radiation Protection Division, Canadian Department of National Health and Welfare, Ottawa, Canada (June 1964).

Analytical Methods

Radiochemical methods are used for the analysis of iodine-131 (*8*). For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet and evaporated under infra-red lamps. The residue is ashed in a muffle furnace at 450°C, dissolved in dilute nitric acid, and strontium separated by fuming nitric acid precipitation. The combined strontium-89 and strontium-90 are determined by counting in a low background beta counter. Strontium-90 is determined separately by extracting and counting the yttrium-90 daughter nuclide while strontium-89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium-137 is determined by gamma spectroscopy using a scintillation crystal and a multi-channel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium-40 and cesium-137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method, the potassium-40 concentration is determined and the Compton contribution of this radionuclide to the cesium-137 photopeak is subtracted to obtain the cesium-137 concentration. The stable potassium content is estimated from the potassium-40 concentration.

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the determination of cesium-137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 8.

TABLE 8.—TOTAL ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS IN MILK [a]

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Strontium-89	±25%	±20%	±15%
Strontium-90	±15%	±10%	±10%
Iodine-131	±50%	±20%	±10%
Cesium-137	±60%	±25%	±10%

[a] All errors are 2σ values, representing 95 percent confidence.

Results

Table 9 presents monthly averages of strontium-90, cesium-137 and stable calcium and potassium in Canadian whole milk. Spot checks for iodine-131 and strontium-89 indicate that all samples had <5 pc/liter.

TABLE 9.—RADIONUCLIDES IN CANADIAN WHOLE MILK, MAY 1964

[Radionuclide concentrations in pc/liter]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90	Cesium-137
Calgary	1.38	1.4	54.7	271
Edmonton	1.41	1.5	41.9	235
Ft. William	1.34	1.5	67.4	304
Fredericton	1.42	1.5	52.9	341
Halifax	1.48	1.6	42.1	254
Montreal	1.39	1.6	41.1	255
Ottawa	1.42	1.7	32.7	207
Quebec	1.38	1.6	47.7	302
Regina	1.35	1.6	57.6	175
St. John's, Nfld	1.39	1.6	40.8	268
Saskatoon	1.39	1.6	61.2	181
Sault Ste. Marie	1.42	1.6	46.1	215
Toronto	1.40	1.6	19.5	141
Vancouver	1.46	1.6	64.3	442
Windsor	1.46	1.6	19.4	98
Winnipeg	1.33	1.6	49.3	224
Average	1.40	1.6	46.4	245

Note: Strontium-89 and iodine-131 levels not reported because of insignificantly low levels (5 pc/liter or less).

131

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MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, JUNE 1963—MAY 1964

Division of Radiological Health, Public Health Service

Radionuclide concentration values reported by the Pasteurized Milk Network (*1*) can be used to estimate the contribution of milk to a population's radiation exposure. This is done by determining both the annual average concentrations of specific radionuclides in milk and the average daily milk consumption of a representative individual in a suitable sample of the population.

The data listed in table 1 are concerned with the first of these requirements, *i.e.*, annual average concentrations of strontium-89, strontium-90, and cesium-137 in one liter of pasteurized milk. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U. S. population (*2, 3*).

To arrive at a basis of comparison between the daily rates of intake of the radionuclides from the milk component of the diet and the Federal Radiation Council's ranges of transient daily rates of intake (*4*), it is assumed that the average daily milk consumption of an individual in a population group is one liter. The Guides, however, apply to total intake from all sources. The upper limits of Range II correspond to the Radiation Protection Guide (RPG) for iodine-131 and to one-third of the RPG for radioactive strontium. The Guides are, for administrative reasons, expressed as a yearly radiation dose, but are based on lifetime exposure (*5*). The FRC emphasizes that the annual acceptable risk or exposure dose is not a dividing line between safety and danger in actual radiation situations (*6*).

Annual averages of radionuclide concentrations in milk sampled by the PHS Pasteurized Milk Network are presented in table 1. The data in table 1 are calculated as follows: Results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of twelve consecutive months are averaged to obtain the annual average.[1] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk.

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as weather conditions and dairying practices. The moving yearly average (table 1), obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

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[1] Beginning with the October 1963 data, iodine-131 values of <10 pc/liter are considered to be zero for averaging purposes; previously, 5 pc/liter was used for calculating the averages.

TABLE 1.—MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK[a]

[Concentrations in pc/liter]

Sampling locations		Strontium-89		Strontium-90		Cesium-137	
		May 1963[b] April 1964	June 1963[c] May 1964	May 1963[b] April 1964	June 1963[c] May 1964	May 1963[b] April 1964	June 1963[c] May 1964
Ala:	Montgomery	31	21	23	23	91	91
Alaska:	Palmer	27	25	24	25	149	157
Ariz:	Phoenix	6	4	4	4	24	25
Ark:	Little Rock	64	47	45	47	168	167
Calif:	Sacramento	21	12	11	9	65	60
	San Francisco	31	16	13	12	75	69
Colo:	Denver	22	20	19	20	93	95
Conn:	Hartford	21	18	26	27	183	184
Del:	Wilmington	25	20	27	27	148	150
D. C:	Washington	33	24	20	20	106	106
Fla:	Tampa	15	12	15	15	235	241
Ga:	Atlanta	49	34	33	33	161	161
Hawaii:	Honolulu	16	10	11	11	82	83
Idaho:	Idaho Falls	47	43	30	31	178	187
Ill:	Chicago	18	16	21	21	125	130
Ind:	Indianapolis	24	18	24	24	112	112
Iowa:	Des Moines	51	35	28	28	102	101
Kans:	Wichita	35	30	22	23	80	81
Ky:	Louisville	65	50	35	36	125	122
La:	New Orleans	51	38	47	49	162	163
Maine:	Portland	26	24	34	34	228	235
Md:	Baltimore	42	33	23	23	133	133
Mass:	Boston	31	28	37	38	261	270
Mich:	Detroit	15	14	21	21	124	128
	Grand Rapids	16	15	22	23	132	137
Minn:	Minneapolis	47	44	34	35	166	171
Miss:	Jackson	53	36	39	40	121	120
Mo:	Kansas City	56	43	31	30	96	95
	St. Louis	41	31	25	26	96	98
Mont:	Helena	43	37	31	32	207	214
Nebr:	Omaha	44	34	28	28	107	109
Nev:	Las Vegas	14	12	11	11	81	84
N. H:	Manchester	28	25	36	37	280	288
N. J:	Trenton	21	17	22	22	138	141
N. Mex:	Albuquerque	16	13	12	12	54	56
N. Y:	Buffalo	21	18	24	24	156	161
	New York	29	27	31	32	188	194
	Syracuse	24	21	25	26	156	163
N. C:	Charlotte	50	39	34	35	131	134
N. Dak:	Minot	80	66	58	60	157	163
Ohio:	Cincinnati	27	21	28	27	105	105
	Cleveland	22	19	23	23	123	127
Okla:	Oklahoma City	41	28	24	24	93	89
Ore:	Portland	50	34	33	32	177	175
Pa:	Philadelphia	24	18	24	24	140	142
	Pittsburgh	31	27	31	32	168	174
P. R:	San Juan	25	17	13	13	88	85
R. I:	Providence	23	20	29	29	186	190
S. C:	Charleston	32	21	29	30	136	142
S. Dak:	Rapid City	59	52	43	45	170	174
Tenn:	Chattanooga	68	49	42	42	158	156
	Memphis	51	36	33	34	95	94
Tex:	Austin	14	11	9	10	48	49
	Dallas	32	21	21	21	84	81
Utah:	Salt Lake City	30	29	27	28	186	193
Vt:	Burlington	25	23	30	31	203	210
Va:	Norfolk	31	23	23	23	109	109
Wash:	Seattle	45	31	27	28	161	159
	Spokane	45	34	31	31	154	154
W. Va:	Charleston	55	40	31	31	110	108
Wis:	Milwaukee	16	15	21	21	136	142
Wyo:	Laramie	35	29	24	24	120	120
Network average		34	27	26.6	27	136	138

[a] All iodine-131 annual averages were <10 pc/liter.

[b] Averages compiled on a 52-week basis.

[c] Averages compiled on a 53-week basis.

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(*6*) Public Health Service: Special Report, *Radiological Health Data, 3: ii–iii,* Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (September 1962).

STRONTIUM-90 IN TRI-CITY DIETS, NOVEMBER 1963–JANUARY 1964[1]

Health and Safety Laboratory, AEC

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium–90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these three cities about every 3 months and are analyzed for strontium–90. Using data from the U. S. Department of Agriculture (*1*) the annual consumption by an average individual can be grouped into the same 19 food categories. The annual dietary intake of strontium–90 can be estimated by summing the contributions from each category. Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data (*1*) are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

After two samplings at each city it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses of dietary components were performed for the third time recently, and further confirmed this result (*2*). Calcium analyses were therefore discontinued and average calcium content of foods was computed and used to estimate the average annual intake of this mineral. Details of the sampling system and a discussion of the results obtained have been summarized (*3*).

Results obtained from the November 1963-January 1964 sampling are presented in table 1. The variation with time of the daily intake of strontium–90 in the three cities is plotted in figure 1.

Discussion

The previously noted geographic pattern of distribution of strontium–90 in the diet is seen to persist in the last sampling: levels have been highest in New York City and lowest in San Francisco. Partly due to its high annual consumption, milk continues to be the predominant source of strontium–90 in the diet.

TABLE 1.—AVERAGE PER PERSON DIETARY CONSUMPTION AND STRONTIUM-90 INTAKE

Food category	Average U.S. consumption		New York City November 1963		Chicago January 1964		San Francisco December 1963	
	Diet (kg/yr)	Calcium (g/yr)	pc/kg •	pc/yr	pc/kg •	pc/yr	pc/kg •	pc/yr
Bakery products	37	37.0	32.8 ±1.30	1,212	28.54 ±1.70	1,056	23.4 ±1.45	866
Whole grain products	11	10.0	83.3 ±1.36	916	80.7 ±2.62	888	25.0 ±1.40	275
Eggs	16	9.1	4.2 ±0.09	67	8.6 ±0.29	138	5.0 ±0.28	80
Fresh vegetables	43	15.0	29.6 ±0.62	1,274	18.2 ±0.63	783	5.4 ±0.41	232
Root vegetables	17	6.1	7.8 ±0.39	133	9.0 ±0.40	153	10.9 ±0.58	186
Milk	221	234.3	27.7 ±0.71	6,115	18.0 ±0.62	3,978	11.8 ±0.50	2,610
Poultry	17	9.2	2.3 ±0.07	38	3.7 ±0.01	62	2.1 ±0.08	36
Fresh fish	8	10.8	2.0 ±0.15	16	1.3 ±0.14	10	0.8 ±0.14	7
Flour	43	8.6	34.8 ±0.71	1,497	28.7 ±0.58	1,232	17.7 ±0.47	762
Macaroni	3	0.7	14.3 ±0.13	43	21.9 ±0.43	66	11.6 ±0.53	35
Rice	3	1.1	7.7 ±0.24	23	4.4 ±0.28	13	2.0 ±0.36	6
Meat	73	10.9	0.8 ±0.09	55	1.2 ±0.07	88	2.0 ±0.08	149
Shellfish	1	0.8	4.4 ±0.23	4	1.4 ±0.25	1	12.2 ±0.36	12
Dried beans	3	2.9	38.2 ±1.94	115	37.8 ±2.22	114	10.6 ±1.47	32
Fresh fruit	68	13.6	7.0 ±0.33	475	4.8 ±0.22	328	1.9 ±0.20	133
Potatoes	45	5.8	6.5 ±0.44	287	7.6 ±0.08	341	2.6 ±0.36	115
Canned fruit	26	1.3	2.3 ±0.14	59	2.4 ±0.17	61	1.7 ±0.13	45
Fruit juices	19	1.7	6.7 ±0.35	127	7.6 ±0.49	145	3.2 ±0.32	61
Canned vegetables	20	4.2	14.6 ±0.58	291	9.1 ±0.65	181	2.5 ±0.41	49
Annual intake	674	383		12,747		9,638		5,691
pc Sr^{90}/g Ca in total diet				33.3		25.2		14.9

• Error terms are one standard deviation (due to counting).

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[1] Summarized from *Fallout Program Quarterly Summary Report, HASL–146*:183–5, Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (July 1, 1964), price $3.50.

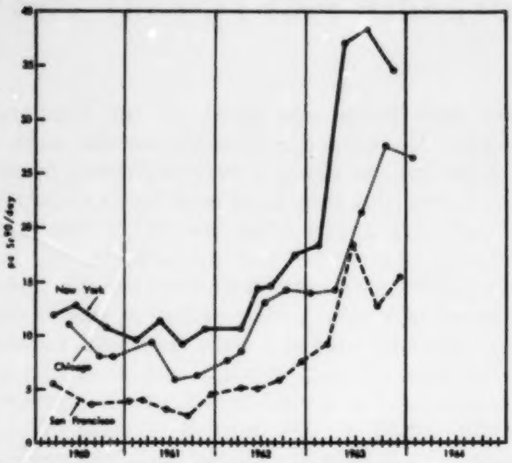

FIGURE 1.—DAILY INTAKE OF STRONTIUM-90 IN TRI-CITY TOTAL DIETS

In New York City and Chicago the strontium-90 intakes were about the same as those found three months earlier. There was a slight increase in the strontium-90 intake estimated for San Francisco. The average Sr-90/Ca ratio in the diets at the three cities during 1963 were 30, 19, and 14 pc/g Ca for New York City, Chicago, and San Francisco, respectively.

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(*2*) U. S. Atomic Energy Commission: *Fallout Program Quarterly Summary Report, HASL-144*:281-7, Office of Technical Services, Department of Commerce, Washington, D. C. 20230 (April 1, 1964), price $4.00. Summarized in *Radiological Health Data*, p. 285-8, June 1964.

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Recent coverage in *Radiological Health Data:*

Period	Issue
Thirteenth sampling (May-July 1963)	*March 1964*
Fourteenth sampling (August-October 1963)	*June 1964*

CESIUM-137 IN TRI-CITY DIETS, OCTOBER-DECEMBER 1962[1]

Joseph Rivera and John J. Kelly[2]

Since March 1960, the Health and Safety Laboratory diet study has made estimates of the strontium-90 content of the average diets of individuals living in New York City, San Francisco, and Chicago (see preceding article, p. 433). Occasionally, some samples from this study are analyzed for cesium-137.

Anderson *et al.* (*1*) showed that cesium-137 levels in fallout, milk, and people could be related, but a number of assumptions as to the magnitude of the contamination of nonmilk fractions of the diet, and the time lag between production and consumption of these foods had to be made before good agreement between observation and theory could be obtained. In an attempt to verify these assumptions and to obtain more data to base predictions of future body levels of cesium-137 in humans, a limited number of samples from the Tri-City Diet Study are being analyzed for cesium-137. The fourth quarter 1962 results of these analyses are presented in table 1. Fourth quarter 1963 results have previously been published (*2*). A comparison of both 1962 and 1963 results may be seen in figure 1.

Analytical Method

The radiochemical analysis of the food composites was accomplished using the procedure developed in this laboratory (*3*). This method has been briefly described elsewhere (*2*).

Experiments to establish the precision and accuracy of cesium-137 analyses are continuing. The reproducibility of six pairs of blind duplicates analyzed with the samples reported here was, as in the last report, better than ±10 percent.

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[1] Data from *Fallout Program Quarterly Summary Report, HASL-146*:233-5, Office of Technical Services, Department of Commerce, Washington, D. C. 20230 (July 1, 1964), price $3.50.

[2] Mr. Rivera is a physicist and Mr. Kelly is a member of the staff of the Environmental Studies Division, Health and Safety Laboratory, U. S. Atomic Energy Commission, 376 Hudson Street, N.Y.C. 10014.

TABLE 1.—AVERAGE PER PERSON DIETARY CONSUMPTION AND CESIUM-137 INTAKE OCTOBER–DECEMBER 1962

Food category	U.S. consumption kg/yr	New York City November 1962		Chicago October 1962		San Francisco December 1962	
		[a] pc/kg	pc/yr	[a] pc/kg	pc/yr	[a] pc/kg	pc/yr
White bread	37	11.9 ±2.0	440	53.3 ±2.7	1,972	39.9 ±2.1	1,476
Whole grain products	11	63.4 ±3.3	697	45.0 ±2.5	495	59.1 ±2.6	650
Eggs	16	6.2 ±0.4	99	13.8 ±0.3	221	0.5 ±0.8	8
Fresh vegetables	43	10.3 ±0.9	443	5.5 ±0.2	237	3.2 ±0.6	138
Root vegetables	17	14.9 ±0.8	253	4.8 ±0.8	82	3.9 ±0.5	66
Milk	221	59.7 ±1.5	13,194	37.4 ±1.3	8,265	17.1 ±0.9	3,779
Poultry	17	15.2 ±0.4	258	5.9 ±0.3	100	18.1 ±0.4	308
Fresh fish	8	9.6 ±0.4	77	63.2 ±1.6	506	20.8 ±0.5	166
Flour	43	40.5 ±1.0	1,742	45.7 ±1.1	1,965	23.6 ±0.8	1,015
Macaroni	3	56.9 ±1.3	171	39.3 ±1.5	118	53.2 ±1.9	160
Rice	3	36.0 ±1.5	108	18.9 ±1.1	57	16.0 ±0.7	48
Meat	73	35.1 ±0.6	2,562	57.5 ±0.9	4,198	42.1 ±0.8	3,073
Shellfish	1	10.4 ±0.6	10	8.0 ±0.3	8	3.8 ±0.2	4
Dried beans	3	11.9 ±2.3	36	24.8 ±3.0	74	59.8 ±4.7	179
Fresh fruit	68	20.9 ±0.9	1,421	11.4 ±1.1	748	4.1 ±0.5	279
Potatoes	45	16.2 ±1.0	729	8.9 ±0.6	401	7.8 ±0.9	351
Canned fruit	26	7.2 ±0.3	187	24.5 ±1.7	637	8.4 ±0.4	218
Fruit juices	19	11.7 ±0.5	222	14.0 ±0.9	266	8.7 ±0.5	165
Canned vegetables	20	10.2 ±1.0	204	31.4 ±1.5	628	4.1 ±0.8	82
Annual intake	674		22,853		20,978		12,165
Daily intake (pc/day)			63		57		33

[a] Error terms are one standard deviation (due to counting).

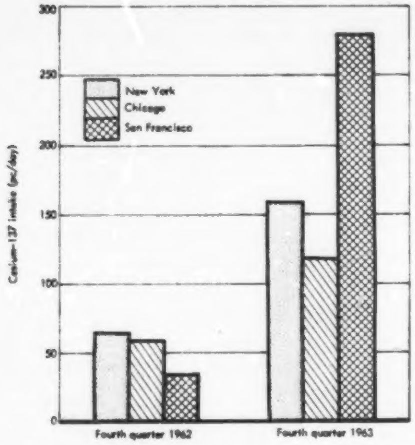

FIGURE 1.—DAILY INTAKE OF CESIUM–137, TRI-CITY DIETS

Some estimate of the accuracy of interlaboratory calibrations of standard solutions used in determining the efficiency of the counters for cesium–137 activity may be seen from table 2. From this table it is evident that calibration differences among laboratories of about 10 percent may exist.

As was discussed in the previous report, there is a possibility that the cesium–137 values may be low due to ashing at high temperatures (500–600°C.). To test this, a milk sample was divided into two parts; half was wet-ashed prior to radiochemical analysis and the other half was dry ashed before analysis. The entire liquid milk sample was also analyzed by gamma-ray spectroscopy for cesium–137 before ashing. The results of (1) gamma spectroscopy, (2) wet ashing, and (3) dry ashing in units of pc Cs^{137}/sample are 200 ±5, 172 ±2, and 176 ± 3, respectively.

TABLE 2.—INTERCOMPARISON OF CESIUM-137 STANDARDS BY 4π BETA COUNTING

Name of standard and analyzing laboratories	Results (disintegration/min./sample)
National Bureau of Standards standard	
National Bureau of Standards	[a] 3.38×10^5
Health and Safety Laboratory	2.93×10^5
Los Alamos Scientific Laboratory	3.22×10^5
Isotopes, Incorporated	3.08×10^5
Atomic Energy of Canada, Ltd, standard	
Atomic Energy of Canada, Ltd	1.49×10^5
Health and Safety Laboratory	1.48×10^5
Los Alamos Scientific Laboratory	1.46×10^5
Isotopes, Incorporated	1.48×10^5
Atomic Energy Research Establishment standard	
Atomic Energy Research Establishment	2.39×10^5
Health and Safety Laboratory	2.35×10^5
Nuclear Chicago standard	
Nuclear Chicago	[a] 7.20×10^6
Health and Safety Laboratory	6.61×10^6
International Atomic Energy Agency standard	
International Atomic Energy Agency	2.242×10^7
Health and Safety Laboratory	2.177×10^7

[a] Calculated from gamma activity measurements.

136

From this experiment it is concluded that no appreciable cesium-137 was lost due to the ashing temperature, but that gamma spectroscopy may yield a higher cesium-137 value than chemical analysis. Many more experiments of this type will of course have to be done to establish this with certainty.

Discussion

As was expected from the strontium-90 fallout levels, the concentrations of cesium-137 in foods purchased at the end of 1962 were very much less than at the end of 1963. The estimated daily intakes of cesium-137 from the 1962 and 1963 samplings were 63 and 156 pc/day in New York City, 57 and 116 pc/day in Chicago and 33 and 278 pc/day in San Francisco. With no other information available, it may be concluded that the best estimate of cesium-137 intake during 1963 would be the arithmetic average which was 110 pc/day in New York City, 90 pc/day in Chicago and 160 pc/day in San Francisco. From the data of Brar *et al.* (*4*), it may be concluded that the cesium-137 intake in Chicago during 1963 was about 160 pc/kg. For individual components Brar's results are usually higher than HASL's results by a factor somewhat less than two. Reasons for this discrepancy are under investigation.

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(*3*) U. S. Atomic Energy Commission: *Manual of Standard Laboratory Procedures, NYO-4700*, Health and Safety Laboratory, AEC, 376 Hudson St., New York, N. Y. 10014, (Revised August 1962).

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Section III—Water

RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, MARCH 1964

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this system has expanded to 130 stations as of July 1, 1964. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U. S. river basins for physical, chemical, biological and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the system provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be subjected. Data assembled through the System and exact locations of sampling points are published in an annual compilation (*1–7*).

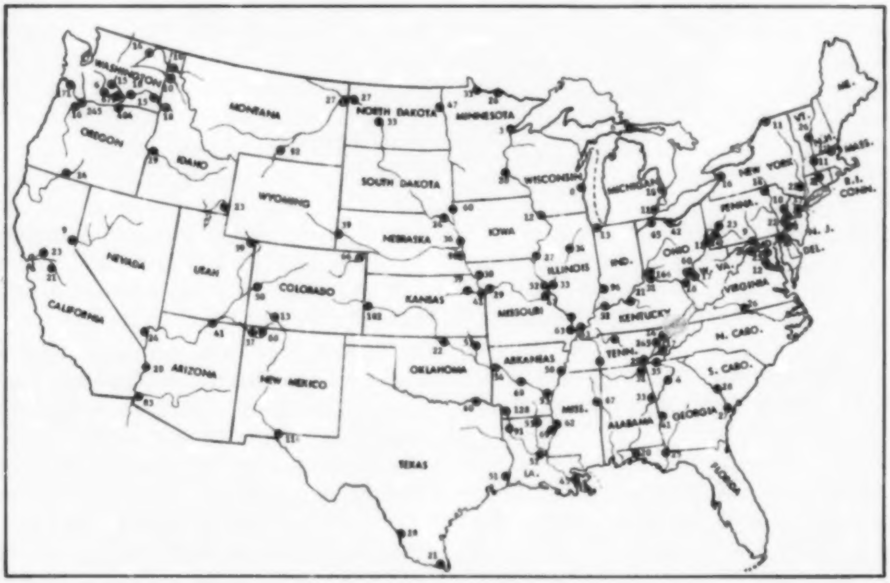
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LA.
WISCONSIN
ILLINOIS
MISS.
MICHIGAN
IND.
KENTUCKY
TENN.
ALABAMA
OHIO
W. VA.
GEORGIA
FLORIDA
VIRGINIA
N. CARO.
S. CARO.
PENNA.
NEW YORK
N. J.
DEL.
CONN.
R.I.
MASS.
VT.
N.H.
ME.

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATERS, MARCH 1964

Sampling Procedures

The participating agencies collect one-liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary. Strontium-90 analyses are performed quarterly.

Presently, gross alpha and beta determinations are made on monthly composites of the weekly samples received from most stations. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are also conducted at all newly established System stations for the first year of operation.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

Analytical Methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*8*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counters.

Results

Table 1 presents March 1964 results of alpha and beta analyses of U. S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first station listed being closest to the headwaters. These data are preliminary. Replicate analyses of some samples as well as some analyses incomplete at the time of this report will be included in the System's Annual Compilation of Data (*7*). The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter. When all samples have zero pc/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5 the mean is reported as <1 pc/liter.

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the March 1964 average total beta activity in suspended-plus-dissolved solids in raw water collected at that station. Results for the years 1957–1962 have been summarized by Weaver *et al.* (*9*). The most recent strontium-90 results appeared in the August 1964 issue of *RHD* (*10*).

Discussion

The monthly dissolved beta activity averages exceeded 100 pc/liter only on the Columbia and Clinch Rivers. Of the six stations on the Columbia River, the four downstream from the Hanford Atomic Products Operations facility had averages of between 143 and 610 pc/liter. It can be observed that the concentration diminishes with distance downstream from the facility.

The dissolved alpha activity, which is associated with the dissolving of natural surface minerals by water, range in monthly averages to 42 pc/liter. Of all stations, four on different rivers had monthly average dissolved alpha activity greater than 10 pc/liter.

While there are no generally applicable standards for surface waters, the radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (*11*). The Public Health Service Drinking Water Standards state that in the absence of strontium-90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentration does not exceed 1000 pc/liter (*12*).

139

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, MARCH 1964

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River:						
Pittsbugh, Pa	14	9	23	1	0	1
Animas River:						
Cedar Hill, N. Mex	70	18	88	13	3	16
Apalachicola River:						
Chattahoochee, Fla	5	20	25	0	0	0
Arkansas River:						
Coolidge, Kansas	48	54	102	5	30	35
Ponca City, Okla	4	18	22	0	1	1
Fort Smith, Ark	23	31	54	1	0	1
Little Rock, Ark	42	26	68	6	1	7
Pendleton Ferry, Ark	37	16	53	3	0	3
Bear River:						
Preston, Idaho	1	22	23	0	0	0
Big Horn River:						
Hardin, Mont	67	25	92	12	6	18
Big Sioux River:						
Sioux Falls, S. Dak	0	60	60	0	2	2
Chattahoochee River:						
Atlanta, Ga	1	3	4	0	0	0
Columbus, Ga	23	18	41	3	1	4
Lenett, Ala	23	10	33	1	0	1
Chena Slough:						
Fairbanks, Alaska	2	6	8	0	1	1
Clearwater River:						
Lewiston, Idaho	7	11	18	0	0	0
Clinch River:						
Clinton, Tenn	4	10	14	<1	<1	<1
Kingston, Tenn	19	226	245	0	1	1
Colorado River:						
Loma, Colo	22	28	50	4	8	12
Page, Ariz	1	40	41	0	9	9
Boulder City, Nev	1	23	24	0	5	5
Parker Dam, Calif-Ariz	2	18	20	0	5	5
Yuma, Ariz	6	77	83	1	8	9
Columbia River:						
Northport, Wash	7	7	14	1	1	2
Wenatchee, Wash	3	12	15	0	1	1
Pasco, Wash	69	610	679	0	1	1
McNary Dam, Ore	34	370	404	0	1	1
Bonneville, Ore	9	236	245	0	1	1
Clatskanie, Ore	28	143	171	0	<1	<1
Connecticut River:						
Wilder, Vt	10	16	26	0	0	0
Northfield, Mass	1	10	11	0	0	0
Enfield Dam, Conn	8	13	21	0	0	0
Cumberland River:						
Clarksville, Tenn		No Re	port			
Cuyahoga River:						
Cleveland, Ohio	17	25	42	1	0	1
Delaware River:						
Martins Creek, Pa	3	15	18	0	0	0
Trenton, N. J	6	10	16	0	0	0
Philadelphia, Pa	13	9	22	1	0	1
Escambia River:						
Century, Fla	9	11	20	0	0	0
Great Lakes:						
Duluth, Minn	0	3	3	0	0	0
Sault Ste. Marie, Mich	0	6	6	1	0	1
Milwaukee, Wisc	1	7	8	0	0	0
Gary, Ind	3	10	13	0	0	0
Port Huron, Mich	7	9	16	0	0	0
Detroit, Mich	2	9	11	0	1	1
Buffalo, New York	1	15	16	0	0	0
Green River:						
Dutch John, Utah	3	36	39	0	4	4
Hudson River:						
Poughkeepsie, N. Y	5	17	22	0	1	1
Illinois River:						
Peoria, Ill	15	19	34	1	0	1
Grafton, Ill	21	31	52	1	2	3
Kanawha River: Winfield Dam, W. Va	14	3	17	1	0	1
Kansas River:						
De Soto, Kansas	7	32	39	1	3	4
Klamath River:						
Keno, Oreg	6	18	24	0	0	0
Little Miami River:						
Cincinnati, Ohio	142	24	166	20	1	21
Maumee River:						
Toledo, Ohio	28	37	65	2	1	3
Merrimack River:						
Lowell, Mass	6	11	17	0	0	0
Mississippi River:						
St. Paul, Minn	4	16	20	0	1	1
Dubuque, Iowa	0	12	12	0	1	1
Burlington, Iowa	9	18	27	1	2	3
E. St. Louis, Ill	12	21	33	1	1	2
Cape Girardeau, Mo	39	24	63	7	1	8
W. Memphis, Ark	46	12	58	7	0	7
Vicksburg, Miss	44	18	62	5	0	5
Delta, La	54	15	69	14	0	14
New Orleans, La	29	14	43	7	0	7
Missouri River:						
Williston, N. Dak	6	21	27	0	5	5
Bismarck, N. Dak	3	30	33	0	2	2
Yankton, S. Dak	4	20	24	0	3	3
Omaha, Nebr	16	20	36	2	2	4
St. Joseph, Mo	18	20	38	2	4	6
Kansas City, Kans	20	21	41	2	5	7
Missouri City, Mo	8	21	29	1	3	4
St. Louis, Mo	24	23	47	2	5	7
Monongahela River:						
Pittsburgh, Pa	16	8	24	0	0	0
North Platte River:						
Henry, Nebr	4	35	39	0	30	30
Ohio River:						
Toronto, Ohio	4	8	12	1	0	1
Addison, Ohio	49	11	60	7	1	8
Huntington, W. Va	6	12	18	0	0	0
Cincinnati, Ohio	22	9	31	3	0	3
Louisville, Ky	12	9	21	1	0	1
Evansville, Ind	43	9	52	3	0	3
Cairo, Ill	50	13	63	4	1	5
Ouachita River:						
Bastrop, La	24	29	53	3	0	3
Pend Oreille River:						
Albeni Falls Dam, Idaho	4	6	10	0	1	1
Platte River:						
Plattsmouth, Nebr	66	30	96	8	8	16
Potomac River:						
Williamsport, Md	0	9	9	0	0	0
Great Falls, Md	12	13	25	1	0	1
Washington, D.C	5	7	12	0	0	0
Rainy River:						
Baudette, Minn	4	29	33	0	0	0
International Falls, Minn	2	24	26	0	0	0
Raritan River:						
Perth Amboy, N. J. (5 ft. Below Surface)	3	14	17	0	4	4
Perth Amboy, N. J. (5 ft. Above Bottom)	2	8	10	2	3	5
Red River, North:						
Grand Forks, N. Dak	3	44	47	0	0	0
Red River, South:						
Denison, Tex	2	58	60	0	0	0
Index, Ark	105	23	128	13	1	14
Bossier City, La	62	29	91	8	1	9
Alexandria, La	46	6	52	5	0	5
Rio Grande River:						
Alamosa, Colo	4	9	13	0	1	1
El Paso, Tex	91	25	116	5	2	7
Laredo, Tex	8	20	28	0	5	5
Brownsville, Tex	3	18	21	0	3	3
Roanoke River:						
John H. Kerr Resr/Dam, Va	10	16	26	1	0	1
Sabine River:						
Ruliff, Tex	16	35	51	1	0	1
Sacramento River:						
Greens Landing, Calif	19	4	23	0	0	0
St. Lawrence River:						
Massena, N. Y	0	11	11	0	0	0
San Joaquin River:						
Vernalis, Calif	6	15	21	1	9	10
San Juan River:						
Shiprock, N. Mex	7	30	37	0	13	13
Savannah River:						
North Augusta, S. C	14	14	28	2	1	3
Port Wentworth, Ga	7	20	27	1	0	1
Schuylkill River:						
Philadelphia, Pa	3	5	8	0	0	0
Shenandoah River:						
Berryville, Va	18	6	24	2	0	2
Ship Creek:						
Anchorage, Alaska	0	2	2	0	0	0
Snake River:						
Ice Harbor Dam, Wash	3	12	15	0	2	2
Wawawai, Wash	5	13	18	1	2	3
Payette, Idaho	5	24	29	1	5	6
South Platte River:						
Julesburg, Colo	14	52	66	0	42	42
Spokane River:						
Post Falls Dam, Idaho						
Susquehanna River:	4	6	10	0	0	0
Sayre, Pa						
Conowingo, Md	5	9	14	0	0	0
Tennessee River:	6	6	12	1	1	2
Lenoir City, Tenn						
Chattanooga, Tenn	8	9	17	0	1	1
Bridgeport, Ala	15	20	35	1	0	1
Pickwick Landing,	16	15	31	2	0	2
Tenn	12	17	29	1	0	1
Tombigbee River:						
Columbus, Miss	45	22	67	5	0	5
Truckee River:						
Farad, Calif	2	7	9	0	0	0
Verdigris River:						
Nowata, Okla	10	43	53	2	6	8
Wabash River:						
New Harmony, Ind	79	17	96	10	1	11
Willamette River:						
Portland, Oreg	9	7	16	0	0	0
Yakima River:						
Richland, Wash	1	5	6	0	1	1
Yellowstone River:						
Sidney, Mont	9	18	27	0	4	4
Maximum	142	610	679	20	42	42
Minimum	0	2	2	0	0	0

Note: These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the network's Annual Compilation of Data (7).

140

REFERENCES

(1) Division of Water Supply and Pollution Control, Public Health Service: *National Water Quality Network Annual Compilation of Data, PHS Publication No. 663, 1958 Edition*, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402. Price $1.50.

(2) *Ibid.*, 1959 Edition. Price $1.75.

(3) *Ibid.*, 1960 Edition.[2]

(4) *Ibid.*, 1961 Edition.[2]

(5) *Ibid.*, 1962 Edition.[2]

(6) *Ibid.*, 1963 Edition (in press).

(7) *Ibid.*, 1964 Edition (to be published).

(8) American Public Health Association, American Water Works Association and Water Pollution Control Federation: *Standard Methods for the Examination of Water and Wastewater*, 11th Edition, New York (1960).

(9) Weaver, L., A. W. Hoadley, and S. Baker: Radioactivity in Surface Waters of the United States, 1957–1962, *Radiological Health Data, 4:* 306–16, (June 1963).

(10) Division of Water Supply and Pollution Control, Public Health Service: Radioactivity in Surface Waters of the United States, February 1964, *Radiological Health Data, 5:*383–86 (August 1964).

(11) Straub, C. P.: Significance of Radioactivity Data, *Journal of the American Water Works Association, 53:*704 (June 1961).

(12) Public Health Service: *Drinking Water Standards, Revised 1962, Public Health Service Publication No. 956*, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (March 1963), price 30 cents.

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[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pc/liter and 10 pc/liter for unidentified alpha emitters and strontium–90, respectively.

[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U. S. Department of Health, Education and Welfare, Washington, D. C. 20201.

RADIOACTIVITY IN CALIFORNIA SURFACE WATERS[1] JULY-DECEMBER 1963

Bureau of Radiological Health, State of California Department of Public Health

Results obtained by the Bureau of Radiological Health in its monitoring of California surface water during the period July to December 1963 are summarized below. The importance of this facet of the Bureau's environmental surveillance program stems from the fact that most of California's domestic water supplies come from surface sources. Radioactivity in such water supplies consists of the natural radioactivity in surface streams, any radioactivity that may be added by the discharge of sewage or industrial waste effluents, and radioactivity from fallout, particularly fallout into open terminal or distribution reservoirs. Most of the supplies sampled represent raw surface waters, although a few wells, along with some water supplies that use infiltration galleries, are also sampled (figure 1).

It is necessary to monitor domestic water supplies on a continuing basis, since it is impossible to forecast levels of radioactivity in these supplies on the basis of radioactivity in rain, snow, or surface streams. The Bureau has established a monthly sampling schedule whereby 500-ml samples are collected and the total solids are analyzed for alpha and beta radioactivity. In addition, a three-liter sample is collected each month for a period of six months to make up a composite of approximately five gallons for strontium–90 analysis.

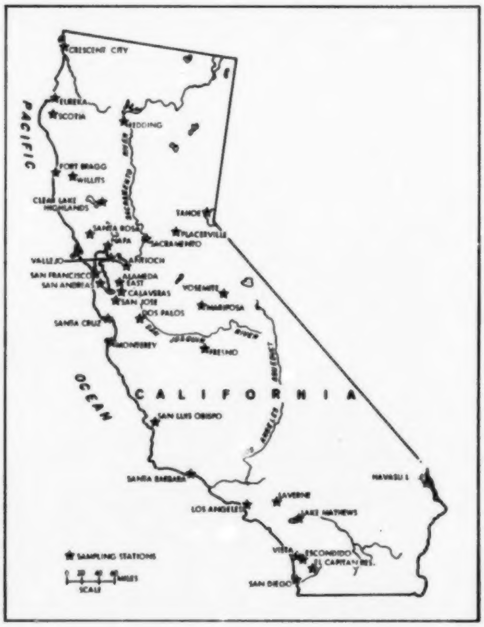
CRESCENT CITY
EUREKA
SCOTIA
PACIFIC
REDDING
FORT BRAGG
WILLITS
CLEAR LAKE HIGHLANDS
TAHOE
SANTA ROSA
PLACERVILLE
NAPA
SACRAMENTO
VALLEJO
ANTIOCH
SAN FRANCISCO
SAN ANDREAS
ALAMEDA EAST
CALAVERAS
YOSEMITE
SAN JOSE
MARIPOSA
LOS PALOS
SANTA CRUZ
MONTEREY
FRESNO
OCEAN
C A L I F O R N I A
SAN LUIS OBISPO
SANTA BARBARA
HAVASU L
LAVERNE
LOS ANGELES
LAKE MATHEWS
VISTA
ESCONDIDO
EL CAPITAN RES.
SAN DIEGO
SAMPLING STATIONS
0 20 40 60 MILES
SCALE

FIGURE 1.—CALIFORNIA SURFACE WATER SAMPLING STATIONS

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[1] Data from "Radiological Health News," Vol. 3 No. 2, April 1964, State of California Department of Public Health, Bureau of Radiological Health, 2151 Berkeley Way, Berkeley 4, California.

TABLE 1.—GROSS BETA ACTIVITY IN CALIFORNIA SURFACE WATER, JULY-DECEMBER 1963

[Concentrations in pc/liter]

Sampling station	July	Aug.	Sept.	Oct.	Nov.	Dec.
Antioch	27.1	[a] 9.3	53.9	[a] 5.0	[a] 19.2	23.8
Chula Vista	[a] 16.0	[b]	37.5	[a] 13.0	[b] 12.3	[b] 1.0
Clearlake Highlands	[a] 19.6	[a] 5.0				[b] 4.1
Crescent City	[a] 4.2	[a] 0	[a] 6.7	38.3	[a] 0	[b] 12.2
Escondido	[a] 23.3	[a] 6.9	[a] 0	[a] 7.5	29.7	40.3
Eureka	[a] 10.7	[a] 8.6	[a] 0	[a] 13.8	[a] 12.2	[b] 16.8
Fort Bragg		[a] 1.5	[a] 9.1			[b] 16.7
Fresno						
Lake Millerton	34.2	32.5	[a] 19.0	29.3	23.8	32.3
Mariposa	[a] 13.6	[a] 0	[a] 16.4	[a] 0.2	[a] 17.6	[b] 9.7
Metropolitan Water District of Southern California						
Lake Havasu	30.3	[a] 13.8	[a] 23.2	[a] 12.3		[b] 12.2
Lake Matthews	[a] 5.1	[a] 25.6	12.4	[a] 23.7	36.2	[b] 1.6
Montrey	39.6	[a] 17.8	[a] 11.9	34.2	[b] 12.7	[b] 17.7
Napa	[a] 0	[a] 8.8			23.8	[b] 5.7
North Marin County Water District	42.3	40.6	23.7	[a] 15.4	31.4	[b] 6.3
Oroville						
Wyandotte Irrigation District		[a] 10.7		[a] 20.3		[b] 14.1
California Water Service	[a] 19.4		[a] 7.9		57.9	
Placerville		[a] 18.1	12.6		[b] 16.5	
Redding	88.0	[a] 12.9	[a] 17.9	[a] 6.5	[b] 5.5	
Sacramento	[a] 14.2	31.4	[a] 12.2	[a] 9.1	[b] 17.7	[b] 6.6
San Francisco Water Department						
Alameda East	68.0	73.1	33.3	[c] 43.2	48.8	23.6
Brightside Weir	[a] 1.3	[a] 2.8	[a] 0	[a] 0	[a] 18.6	[b] 12.6
Calaveras Reservoir	[a] 11.9	[a] 15.1	[a] 0	[a] 0	[a] 13.7	[b] 15.7
Crystal Springs Raw Outlet	[a] 6.3	15.2				
Crystal Springs Line #1		[a,c] 18.2	[a,c] 10.2	[a,c] 15.2	[a,c] 10.2	[c] 21.5
Crystal Springs Line #2				[a,c] 22.2		
Hetch Hetchy	60.5			[a] 17.8	35.8	[b] 12.7
Lombard Reservoir	81.2					
San Andreas Line #2	[a] 6.8	[a,c] 35.0	[a,c] 8.3	[a,c] 11.0	[a] 14.5	[b,c] 15.5
San Jose	[a] 13.3	[a] 0				[b] 0
San Luis Obispo	[a] 14.4	[a] 21.0	[a] 19.6	[a] 18.1	[a] 17.6	[b] 14.7
Santa Barbara		[a] 13.7	[a] 7.8	[a] 6.5	[a] 0	35.1
Santa Cruz	26.4	[a] 15.7		[a] 3.6	[a] 3.5	[b] 12.7
Santa Rosa	100.1	[a] 0	[a] 11.5	[a] 0.7	[a] 8.8	[b] 0
Scotia	[a] 10.7	[a] 4.2	[a] 5.0	[a] 4.1	[a] 13.4	24.0
Tahoe City	22.8		30.9	[a] 4.2	[a] 5.0	[b] 3.6
Vallejo						
Fleming Hill	71.9	25.8	[a] 12.5	[a] 18.7	[a] 19.4	[b] 19.3
Swanzy Reservoir	[a] 20.0	[a] 20.4	[a] 0	[a] 19.2	[a] 8.3	[b] 20.3
Vista	60.8	[a] 24.0	[a] 8.4	[a] 24.3		[b] 11.4
Willits	[a] 16.6	[a] 9.0	[a] 0	[a] 10.2	[a] 14.5	[b] 11.0
Yosemite	45.3	24.8	23.7	21.7	22.6	24.3
Maximum	100.1	73.1	53.9	43.2	57.9	40.3
Minimum	0	0	0	0	0	0

[a] The counting rate of the sample is not equal to at least twice the 95 percent statistical counting error but the value reported is the best available estimate.

[b] Blank space indicates no sample collected or analyzed.

[c] Average of more than one sample for the month.

Laboratory Methods

Radionuclide analyses of water are carried out in the Sanitation and Radiation Laboratory. All measurements of alpha and alpha-plus-beta activities are made with windowless gas-flow proportional counters.

The Department's maximum capacity for alpha and beta radioactivity measurements during a normal work week is 500 thirty-minute counts. Counting methods used are in accordance with U. S. Public Health Service recommended procedures (*1*).

Discussion

Table 1 shows the monthly average beta activity in the suspended-plus-the-dissolved-solids in raw surface water in California from July through December 1963. Following treatment, these waters are used for industrial and domestic purposes. Because alpha activity in water has in general been undetectable or very slight, alpha activity analyses are not presented. Little increase in the radioactivity level of surface water was observed in spite of some increase in fallout.

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Previous coverage in *Radiological Health Data:*

Period	Issue
1961-June 1962	*April 1963*
July-December 1962	*September 1963*
January-June 1963	*March 1964*

RADIOACTIVITY IN NORTH CAROLINA SURFACE, GROUND, AND CISTERN WATERS, NOVEMBER 1961-DECEMBER 1963[1]

Sanitary Engineering Division
North Carolina State Board of Health

In recognition of growing use of radioactive materials in the State of North Carolina, the Sanitary Engineering Division and the State Laboratory of Hygiene of the State Board of Health, with the cooperation of municipalities, began in June 1958 a program of measurement of radioactivity in surface waters used as public water supplies. Some 147 sampling points were established to sample raw surface water. In July 1962, the program was expanded to include the sampling of cistern water from Ocracoke Island. Then, in January 1963 other types of environmental samples were also collected (*1*), two of which were finished water from surface water supplies and ground water from wells used as municipal water supplies.

All waters contain traces of radioactivity originating from naturally radioactive minerals dissolved from rock strata or from radioactive particulate material or gases in the atmosphere. Common among these materials are trace elements of potassium-40, radium, thorium, and uranium. Such trace elements are dissolved by water both on its way to and flowing in the watercourses. Precipitation is the major mechanism by which particulate matter or radioactive gases such as thoron and radon, are removed from the atmosphere.

The combined radioactivity of these materials constitutes what is known as "background radioactivity" of the water. The total activity would include both background radioactivity and contributions from fallout and other man-made sources.

A knowledge of the concentration of the background radioactivity as well as the total activities is an important factor in the appraisal of water quality, since standards pertaining to radiation exposure or concentration within drinking water are expressed in terms of "additions to the natural background" (*2*). Surface water data for 1958 through 1961 are considered as background radioactivity and have previously been published in *RHD* (*3*).

Laboratory Procedure

Total solids content is determined for each sample so that proper sample proportions may be used in analysis. The calculated amount of a sample is concentrated to a few millimeters on a steam bath. The residue is transferred to a stainless steel planchet and evaporated to dryness under an infrared light. After further drying for one hour at 103° C., the sample is cooled in a desiccator and is then counted.

Alpha-plus-beta counting is done in a gas-flow internal proportional counter calibrated with a radium D + E source. On the basis of instrument background (17 counts per minute), each sample is counted for a preset count and the results are reported in terms of picocuries per liter.

Results

Table 1 gives the average gross (alpha plus beta) radioactivity in raw surface water as well as the maximum and minimum values recorded over the period November 1961 through December 1963. The first column consists of code numbers which indicate the geographical positions of the sampling stations shown in figure 1.

After purification of these surface waters, the finished water is distributed for domestic and industrial uses. Finished water from some of these supplies has been sampled for gross radioactivity. Table 2 gives the average, maximum and minimum radioactivity in finished water from these supplies during 1963.

On some of the islands situated along the eastern seaboard of North Carolina (figure 2), drinking water is obtained from small cistern water supplies. The cistern supplies are characteristically constructed with roof prewash valves which permit the diversion of the first runoff and then allow the balance of the rainwater to pass into the cistern. A one-liter sample is usually collected quarterly and analyzed for gross radioactivity. Table 3 presents the results for four cistern supplies on Ocracoke Island, from the fourth quarter of

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[1] Abstracted from "Background Radioactivity in Surface Water Supplies in North Carolina" and "Environmental Surveillance—1963"

143

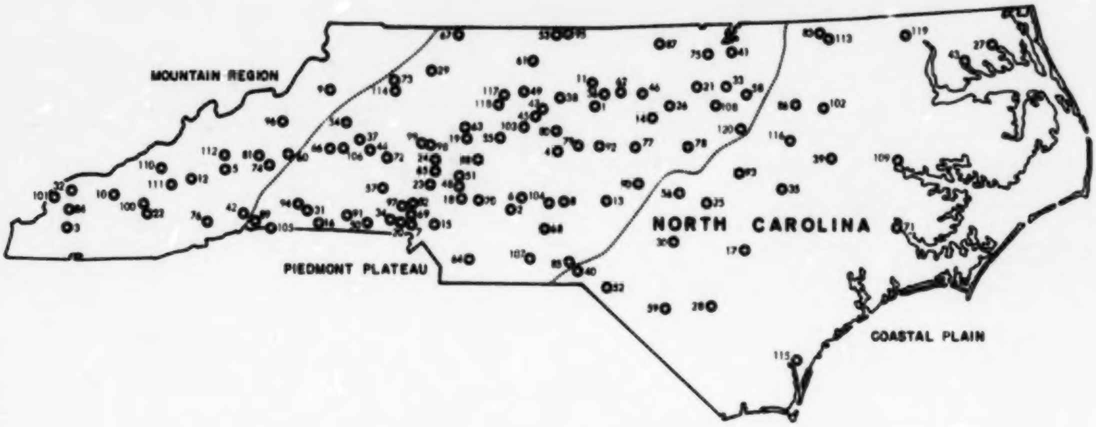
MOUNTAIN REGION
PIEDMONT PLATEAU
NORTH CAROLINA
COASTAL PLAIN

FIGURE 1.—NORTH CAROLINA REGIONS AND SURFACE WATER SAMPLING STATIONS WITH CODE NUMBERS

1962 through the fourth quarter of 1963. The location of Ocracoke Island is shown in figure 2.

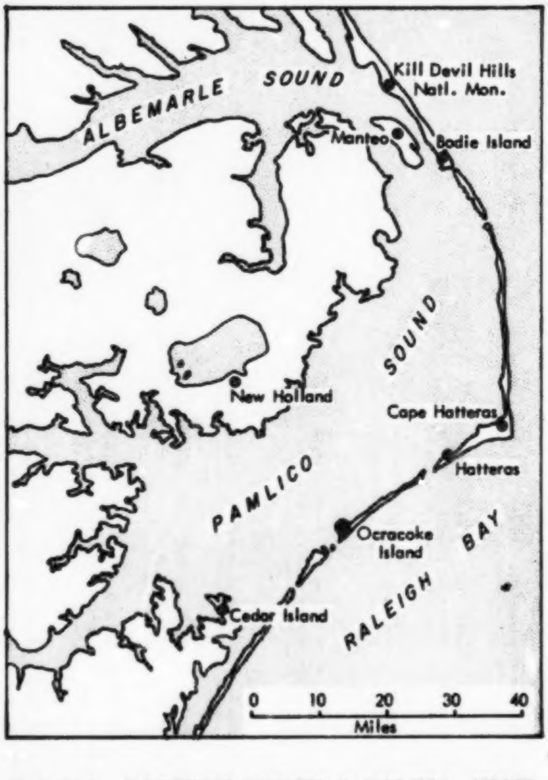
ALBEMARLE SOUND
Kill Devil Hills Natl. Mon.
Manteo
Bodie Island
New Holland
PAMLICO SOUND
Cape Hatteras
Hatteras
Ocracoke Island
RALEIGH BAY
Cedar Island
0
10
20
30
40
Miles

FIGURE 2.—EASTERN NORTH CAROLINA, SHOWING LOCATION OF OCRACOKE ISLAND

Discussion and Interpretation of Data

The measurement of gross radioactivity (alpha-plus-beta) at low levels or low concentrations is difficult because of the many variable factors such as types and energy of radiation, necessary concentration to obtain a representative sample, and counting efficiency (which includes absorption, scatter, and geometry).

All results may be interpreted on the basis of the Public Health Service Drinking Water Standards (*4*) which state that in the absence of strontium-90 and alpha emitters, a water supply is acceptable if the gross beta activity does not exceed 1000 picocuries per liter of water. This value relates to average intake from water over a long period of time and not from transient conditions.

Individual sample data and associated errors have been separately reported (*1*, *2*). The usual two-sigma counting error was from 1 to 5 pc/liter. The significant increased activity recorded in surface water from November 9, 1961, through the years 1962 and 1963 is probably due to the presence of fission material produced during the renewed atmospheric testing of nuclear weapons. The network average radioactivity in surface water was about the same in 1963 as in 1962.

TABLE 1.—GROSS RADIOACTIVITY FOUND IN RAW SURFACE WATER USED AS SOURCES OF PUBLIC WATER SUPPLIES, NORTH CAROLINA, NOVEMBER 1961–DECEMBER 1963

[Alpha-plus-beta concentrations in pc/liter]

Code	Location	Source of water supply	November 1961—1962				1963			
			No. of samples	Average	Maximum [a]	Minimum [b]	No. of samples	Average	Maximum [a]	Minimum [b]
1	Alamance	Big Alamance Creek	0	—	—	—	2	7.7	8.3	7.1
2	Albemarle	Yadkin River	12	17.5	36.6	4.7	12	11.6	21.5	4.7
3	Andrews	Beaver Creek	5	2.9	5.8	1.4	2	1.6	2.3	1.0
4	Asheboro	Back Creek	5	27.9	44.5	19.6	4	24.1	32.1	9.3
5	Asheville	Bee Tree Creek	11	2.9	8.0	1.4	13	7.2	15.1	2.0
6	Badin	Yadkin River	5	21.1	46.2	6.9	1	7.6	7.6	7.6
7	Belmont	Catawba River	5	25.6	53.3	6.1	4	11.6	16.4	6.2
8	Biscoe	Little River	5	11.9	18.4	5.9	3	45.7	109.8	11.1
9	Blowing Rock	Brickhouse Creek	12	12.8	28.6	7.0	4	13.6	26.6	7.2
10	Bryson City	Lands Creek	5	1.4	1.8	1.0	2	7.6	13.7	1.6
11	Burlington	Stony Creek	0	—	—	—	12	26.0	58.7	8.0
12	Canton	Pigeon River; Ruff Creek	4	5.7	6.4	3.0	2	2.8	3.3	2.4
13	Carthage	Spring	5	5.0	7.2	3.3	0	—	—	—
14	Chapel Hill	Price Creek	5	22.4	44.7	10.0	4	20.8	33.1	8.1
15	Charlotte	Catawba River	14	13.8	32.9	3.7	12	13.8	27.5	2.9
16	Cliffside	Second Broad River	13	14.0	90.0	0.9	4	7.1	10.2	0.9
17	Clinton	Black River	10	19.0	34.1	7.6	4	12.2	25.6	1.5
18	Concord	Cold Water Creek & Lumby Creek	13	36.7	79.4	7.0	12	28.0	64.4	10.4
19	Cooleemee	South Fork Yadkin	5	12.3	43.4	6.1	4	13.3	21.3	3.4
20	Cramerton	South Fork Catawba River	5	19.0	54.1	5.5	12	9.5	24.0	3.2
21	Creedmoor	Ledge Creek	5	42.5	74.5	6.4	2	33.4	57.1	9.7
22	Cullowhee	Long Branch; Flat Creek	5	3.9	10.4	2.4	2	0.9	1.7	0.1
23	Davidson	Cathy's Creek	5	13.7	27.7	9.0	2	7.6	10.2	5.0
24	Denton	Lick Branch	5	27.0	38.9	8.7	2	17.0	29.8	4.1
25	Dunn	Cape Fear River	12	40.3	119.0	11.6	4	22.9	33.7	11.3
26	Durham	Flat River	11	30.8	64.2	9.2	13	25.5	69.2	12.3
27	Elizabeth City	Pasquotank River	5	11.6	26.3	5.0	1	3.6	3.6	3.6
29	Elkin	Big Elkin Creek	5	12.0	17.3	4.8	2	4.6	6.8	2.4
30	Fayetteville	Cape Fear River	13	24.2	57.1	7.6	12	43.4	145.5	4.0
31	Forest City	Second Broad River	5	10.6	26.0	1.5	3	5.2	7.5	2.8
32	Fontana Dam	Little Tennessee River	5	7.0	10.4	3.9	2	5.5	6.0	5.0
33	Franklinton	Kearney's Creek	6	28.7	50.4	6.2	2	22.2	37.6	6.7
34	Gastonia	Long Creek; Catawba River	13	17.0	38.4	4.2	12	14.4	46.4	3.2
35	Goldsboro	Little River; Neuse River	0	—	—	—	3	15.7	23.9	10.7
36	Graham	Back Creek	5	20.3	[c] 42.6	10.2	3	16.4	28.2	7.3
37	Granite Falls	Catawba River	5	11.2	18.1	2.8	2	8.8	13.4	4.2
38	Greensboro	Reedy Fork Creek	13	29.4	62.6	7.4	12	30.1	73.0	7.8
39	Greenville	Tar River	10	29.5	[d] 69.4	12.0	21	18.6	42.3	5.1
40	Hamlet	Marks Creek	5	12.4	25.6	2.1	2	22.6	36.6	8.6
41	Henderson	Sandy Creek	4	19.0	[illegible]3.8	8.7	2	23.4	30.1	16.7
42	Hendersonville	North Fork Mills River and Bradley Creek	0	—	—	—	3	2.8	4.1	2.0
43	Hertford	Perquimans River	5	7.6	15.3	0.0	1	2.8	2.8	2.8
44	Hickory	Catawba River	12	7.9	17.3	3.9	12	8.2	16.7	2.8
45	High Point	Deep River	11	43.4	110.2	9.1	12	24.9	68.7	6.5
46	Hillsboro	Eno River	5	15.8	36.3	4.1	4	14.6	25.4	6.7
47	Jamestown	Deep River	3	29.2	53.2	15.3	1	22.6	22.6	22.6
48	Kannapolis	Buffalo Creek	12	26.1	54.0	3.0	12	24.2	41.9	7.0
49	Kernersville	Belew's Creek	7	33.2	58.3	9.1	2	11.2	15.6	6.7
50	Kings Mountain	Kings Creek	5	23.2	59.9	4.5	2	12.8	18.6	7.0
51	Landis	Grant's Creek	5	45.4	75.3	8.4	2	14.3	17.6	11.1
52	Laurinburg	Jordan Creek	5	11.1	16.9	5.2	12	12.1	29.0	4.5
53	Leaksville	Dan River	12	15.7	35.0	3.9	4	9.8	19.0	4.8
54	Lenoir	Zacks Fork Creek & Catawba River	5	10.6	17.8	4.9	3	12.0	13.6	8.9
55	Lexington	Abbott's Creek	5	39.0	70.1	8.0	4	32.3	41.6	24.9
56	Lillington	Cape Fear River	5	35.4	85.0	7.8	2	13.8	16.3	10.4
57	Lincolnton	Walker Branch	6	36.5	145.7	2.7	4	17.4	41.2	1.8
58	Louisburg	Tar River	3	40.4	67.4	18.6	2	12.0	14.6	9.5
59	Lumberton	Lumber River	11	22.7	54.8	5.0	12	16.3	31.9	8.1
60	Marion	Mackey's Creek; Buck Creek	5	7.1	23.0	0.8	1	6.5	6.5	6.5
61	Mayodan	Mayo River	5	13.2	32.8	6.3	1	28.7	28.7	28.7
62	Mebane	Mills Creek	5	11.9	18.1	4.5	1	13.2	13.2	13.2
63	Mocksville	Bear Creek	5	30.1	97.6	6.2	0	—	—	—
64	Monroe	Richardson Creek	5	42.6	76.4	31.4	4	32.9	61.6	5.1
65	Mooresville	Byers Creek; Catawba River	7	15.7	43.5	4.5	4	11.9	17.7	4.7
66	Morganton	Henry River	6	2.4	3.5	1.1	3	3.0	5.2	1.1
67	Mount Airy	Lovell's Creek	1	5.4	5.4	5.4	4	4.4	6.2	2.4
68	Mount Gilead	Pee Dee River	5	22.6	40.2	11.0	4	13.8	22.0	6.0
69	Mount Holly	Catawba River	5	16.2	31.8	7.8	12	11.4	15.8	6.4
70	Mount Pleasant	Dutch Buffalo Creek	6	11.8	17.9	6.0	1	26.0	26.0	26.0
71	New Bern	Neuse River	8	17.5	38.4	6.3	1	11.9	11.9	11.9
72	Newton	Jacobs Fork	0	—	—	—	3	17.7	35.5	5.6
73	North Wilkesboro	Reddies River	12	9.0	40.9	2.4	4	15.9	46.1	1.6
74	Old Fort	Jarrett Creek	5	7.8	18.1	2.6	0	—	—	—
75	Oxford	Tar River; Hatcher's Run	6	54.3	89.6	9.6	1	27.8	27.8	27.8
76	Pisgah Forest	Davidson River	8	4.8	9.2	1.4	1	14.8	14.8	14.8
77	Pittsboro	Robinson Creek	5	46.3	100.7	16.2	2	43.6	61.0	26.3
78	Raleigh	Lake Raleigh; Lake Wheeler	0	—	—	—	9	30.0	54.8	11.3
79	Ramseur	Sandy Creek	6	10.7	34.0	4.3	1	23.2	23.2	23.2
80	Randleman	Pole Cat Creek	6	18.9	47.2	4.4	1	51.6	51.6	51.6

TABLE 1.—Continued.

[Alpha-plus-beta concentrations in pc/liter]

Code	Location	Source of water supply	November 1961—1962				1963			
			No. of samples	Average	Maximum [a]	Minimum [b]	No. of samples	Average	Maximum [a]	Minimum [b]
81	Ridgecrest	Mountain Stream	5	3.6	4.7	2.9	0	—	—	—
82	Riverbend	Catawba River	4	23.9	43.6	7.8	1	19.6	19.6	19.6
83	Roanoke Rapids	Roanoke River	12	15.1	28.8	8.0	4	12.0	18.6	5.6
84	Robbinsville	Rock & Burgin's Creek	4	7.7	23.7	1.3	0	—	—	—
85	Rockingham	Falling Creek	5	2.0	2.1	1.4	4	25.3	36.0	11.6
86	Rocky Mount	Tar River	0	—	—	—	10	25.0	78.7	6.4
87	Roxboro	Lake Isaac Walton; Storey's Creek	6	25.0	50.9	9.5	1	13.4	13.4	13.4
88	Salisbury	Yadkin River	4	4.8	8.6	0.9	11	16.3	48.2	2.8
89	Saluda	Paces Creek	4	4.7	8.6	2.0	0	—	—	—
90	Sanford	Lick Creek; Potterage Creek	6	15.3	25.0	7.6	4	17.9	37.0	10.3
91	Shelby	First Broad River	11	19.6	43.5	3.7	4	7.3	9.4	4.9
92	Siler City	Rocky River	5	53.5	86.8	14.0	4	21.7	34.7	11.4
93	Smithfield	Neuse River	12	25.5	94.7	5.6	11	26.5	56.9	12.6
94	Spindale-Rutherfordton	Hollands Creek; Cathy's Creek	5	12.7	46.2	2.2	1	4.4	4.4	4.4
95	Spray	Smith River	13	15.1	46.8	4.1	12	19.4	101.6	1.7
96	Spruce Pine	Beaver Creek	5	2.9	7.1	1.5	0	—	—	—
97	Stanley	Hoyle's Creek	6	11.8	32.1	3.3	1	32.3	32.3	32.3
98	Statesville	Fourth Creek	5	15.0	62.2	1.1	4	8.1	14.5	3.0
99	Statesville	South Yadkin River	5	21.1	85.3	3.7	5	6.6	9.4	3.6
100	Sylva	Dill's Creek	12	2.7	5.1	0.6	4	3.9	6.8	1.6
101	Tapoco	Yellow Hammer Creek	5	3.3	5.9	1.7	1	4.8	4.8	4.8
102	Tarboro	Tar River	5	38.1	58.4	10.6	4	15.4	32.2	6.8
103	Thomasville	Abbott's Creek	7	32.0	68.8	19.1	4	25.9	37.6	6.2
104	Troy	Denson Creek; Downing Creek	6	7.5	10.5	4.0	1	20.5	20.5	20.5
105	Tryon	Falls Creek; Vaughn's Creek	6	4.4	17.8	2.3	1	4.4	4.4	4.4
106	Valdese	Micol Creek; Hoyle Creek; Catawba River	4	14.3	34.4	3.6	4	9.1	14.5	3.4
107	Wadesboro	Jones Creek	5	34.7	77.6	12.1	1	28.0	28.0	28.0
108	Wake Forest	Smith's Creek	3	10.0	13.0	6.7	1	13.5	13.5	13.5
109	Washington	Tranters Creek	5	37.9	46.5	23.2	1	27.3	27.3	27.3
110	Waterville	Big Creek	4	1.3	1.7	1.0	1	0.8	0.8	0.8
111	Waynesville	Cherry Cive & Shiney Creek	4	6.8	14.4	2.5	2	6.8	8.5	5.3
112	Weaverville	Wagner Branch & Ox Creek	4	2.1	2.8	1.8	1	2.6	2.6	2.6
113	Weldon	Roanoke River	4	29.8	70.6	13.6	1	14.5	14.5	14.5
114	Wilkesboro	Cub Creek	5	6.1	12.4	2.4	1	2.1	2.1	2.1
115	Wilmington	Cape Fear River	12	27.2	85.6	8.3	11	20.8	57.9	11.8
116	Wilson	Contentney Creek	7	24.6	28.6	20.9	0	—	—	—
117	Winston-Salem	Salem Creek	13	19.2	44.5	3.9	9	23.6	36.3	0.8
118	Winston-Salem	Yadkin River	11	13.4	72.0	3.5	10	27.0	35.3	2.3
119	Winton	Chowan River	9	28.4	43.8	15.3	1	16.0	16.0	16.0
120	Zebulon	Little River	5	23.7	77.5	5.5	4	9.9	11.4	7.7
Network summary			757	18.7	145.7	0.0	509	16.2	145.5	0.1

[a] Maximum values have 95 percent accuracy ±20 percent.
[b] Minimum values have 95 percent accuracy ±60 percent.
[c] A value of 156 pc/liter was observed but probably reflects rainfall and was excluded.
[d] A value of 368 pc/liter was observed but probably reflects rainfall and was excluded.

The results for 1963 for ground water, raw surface water, finished water, and cistern water have been summarized in table 4, by region of the State (figure 1).

It is apparent that the coastal region has somewhat greater radioactivity in its ground water than the Piedmont and mountain regions as indicated by averages of 11, 6, and 5 pc/liter, respectively. These activities would be considered as background since the radioactivity present in the water is imparted to the ground waters from the dissolution of geological formations of granite, gneiss, and other bedrock. Radioactivity so imparted would be the combined contribution of such elements as natural uranium, thorium, radium, potassium and other long-lived materials occurring in nature.

It can be noted that the mountain surface waters contain less radioactivity (6 pc/liter) than those in the Piedmont (19 pc/liter) and further east (20 pc/liter). This is to be expected, since the surface waters in the mountains have less mineral content. As these waters flow toward the ocean their dissolved solids content, paralleled by their concentrations of natural radioactivity as well as fallout activity, increases.

The mountain region had an average of 6 pc/liter in finished water while the Piedmont and coastal regions reported averages of 9 and 12 pc/liter. In order to directly compare the results for raw water and finished water, one should refer to the data for individual samples of raw and finished water collected at the same time (*2*). However, it appears that finished

146

TABLE 2. GROSS RADIOACTIVITY IN FINISHED WATER FROM SURFACE WATER SUPPLIES IN NORTH CAROLINA, 1963

[Alpha-plus-beta concentrations in pc/liter]

Code No.	Location	Source of water supply	No. of samples surveyed	Average	Maximum	Minimum
2	Albemarle	Yalkin River	12	7.1	12.3	2.5
5	Asheville	Bee Tree Creek	11	5.3	10.1	1.4
11	Burlington	Stony Creek	12	12.4	19.4	6.6
15	Charlotte	Catawba River	18	8.3	10.6	5.6
18	Concord	Cold water Creek and Lumby Creek	12	14.2	31.6	6.6
20	Cramerton	South Fork Catawba River	12	5.0	18.7	1.2
26	Durham	Flat River	12	10.1	17.4	5.0
30	Fayetteville	Cape Fear River	12	12.7	35.1	5.9
34	Gastonia	Long Creek; Catawba River	12	8.1	13.9	3.2
35	Goldsboro	Little River; Neuse River	3	25.2	61.8	3.5
38	Greensboro	Reedy Fork Creek	12	9.9	16.6	4.8
39	Greenville	Tar River	14	9.0	16.8	4.8
44	Hickory	Catawba River	12	6.5	12.8	2.7
45	High Point	Deep River	12	10.4	14.6	4.9
48	Kannapolis	Buffalo Creek	13	11.2	16.0	4.3
52	Laurinburg	Jordan Creek	11	4.9	7.2	2.0
59	Lumberton	Lumber River	12	8.7	16.1	3.3
69	Mount Holly	Catawba River	12	7.3	15.5	4.3
78	Raleigh	Lake Raleigh; Lake Wheeler	12	12.8	26.3	4.8
86	Rocky Mount	Tar River	12	9.2	17.8	3.2
88	Salisbury	Yadkin River	11	6.5	9.1	3.8
93	Smithfield	Neuse River	11	11.6	27.8	3.5
95	Spray	Smith River	12	5.3	9.2	2.5
115	Wilmington	Cape Fear River	11	10.4	17.4	4.8
117	Winston Salem	Salem Creek	9	7.6	10.8	4.3
118	Winston Salem	Yadkin River	5	9.0	13.0	4.4
Network summary			297	9.6	61.8	1.2

TABLE 3.—GROSS RADIOACTIVITY IN CISTERN WATER AT OCRACOKE ISLAND, NORTH CAROLINA, DECEMBER 1962–DECEMBER 1963

[Alpha-plus-beta concentrations in pc/liter]

Date sampled	Type of supply			
	Public school	National Park Service	Coast Guard station	Private residence
December 16, 1962	68.6	124.4	130.9	115.2
April 8, 1963	98.4	82.5	278.3	226.0
May 27, 1963	140.7	163.8	272.2	19.0
July 19, 1963	169.2	[a]—	230.6	—
December 2, 1963	33.7	35.8	85.4	58.6

[a] Dash indicates no sample.

TABLE 4.—SUMMARY OF RESULTS OF GROSS RADIOACTIVITY IN WATER SUPPLIES IN NORTH CAROLINA 1963

[Alpha-plus-beta concentrations in pc/liter]

Type of water and region	No. of samples	Average	Maximum	Minimum
Ground water				
Mountain region	25	5	14	1
Piedmont region	47	6	13	1
Coastal region	95	11	55	1
Raw surface water				
Mountain region	88	6	18	0
Piedmont region	332	19	109	1
Coastal region	115	20	42	2
Finished water from surface supplies				
Mountain region	11	6	9	4
Piedmont region	202	9	34	2
Coastal region	87	12	21	2
Cistern water				
Ocracoke Island	14	135	278	19

water had on the average lower concentrations than raw water.

It is readily apparent that during 1963 cistern water contained more radioactivity than any of the other types of public water supplies sampled. The range observed was from 19 to 278 pc/liter with an average of 135 pc/liter. These values are more nearly like the values usually observed in precipitation during 1963 than the values for ground and surface water. This may be due to fission products being washed from the atmosphere and from roofs by precipitation.

REFERENCES:

(1) North Carolina State Board of Health Sanitary Engineering Division and State Laboratory of Hygiene: *Background Radioactivity in Surface Water Supplies of North Carolina, 1958–1962.*

(2) North Carolina State Board of Health Sanitary Engineering Division and State Laboratory of Hygiene: *Environmental Surveillance—1963.*

(3) North Carolina State Board of Health, Sanitary Engineering Division: North Carolina Surface Water, June 1958–December 1961, *Radiological Health Data, 4*:259–62 (May 1963).

(4) Public Health Service: *Drinking Water Standards, Revised 1962, Public Health Service Publication No. 956,* Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (March 1963), price 30 cents.

Previous coverage in *Radiological Health Data:*

Period	Issue
June-August 1962 (cistern water)	*February 1963*
June 1958-December 1961	*May 1963*

Section IV—Other Data

SUMMARY OF STATE RADIOLOGICAL ENVIRONMENTAL SURVEILLANCE ACTIVITIES

Carnick A. Markarian, George W. Williams, and Guntis Ozolins[1]

In the past five years, considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have progressed significantly toward achievement of a comprehensive environmental surveillance program and self-sustaining radiological health laboratory. Although a few States have encountered difficulties (mainly personnel and budgetary) in their attempts to initiate such programs, a recent status review showed that 44 States were conducting some form of surveillance by mid-1963.

A graphical summary of State sampling programs is presented and a description of laboratory capabilities and activities follows. The data discussed in the sections on sampling, equipment and analyses were derived from State status reports dated June 30, 1963.[2] The data pertaining to the nuclide distribution and the quality control program are inclusive through May 31, 1964. A detailed evaluation of the latter program and individual State programs are beyond the scope of this summary.

Sample Collection

Shaded portions of figures 1–4 indicate those States which have established air, precipitation, milk and water programs. The total sampling locations in each State is indicated by numbers inscribed within symbols which designate frequency of collection. Routine surveillance activities reflected in the figures may be expanded whenever levels of contamination indicate the need for more extensive surveillance. In addition, some States are conducting sampling of food, shellfish, aquatic biota and other vectors.

The frequency of sampling of a given vector is not necessarily constant within a State. A sampling program may include several daily samples as well as samples collected at longer intervals. The attempt in such cases is to show the predominant sampling frequency. Air is being sampled in 26 States (shown in figure 1), with collection frequencies ranging from daily, the most common, to twice a month. Precipitation sampling is conducted in 15 States at daily or weekly collection intervals as shown in figure 2.

Milk samples are collected by 27 States for analysis. The frequency of collection varies from daily to quarterly. Analyses are usually performed on composite samples collected from individual major dairies or from milk processing plants within a milkshed area. The number of sampling points shown in figure 3 indicates the number of milksheds under surveillance.

Raw surface water and public water supply sampling points have been combined in water surveillance activities (figure 4). A total of 41 States have indicated participation in water sampling, of which 27 State programs include both raw and public supply sampling. Eleven States are sampling only raw surface water, and three are engaged only in surveillance of the public supply. The sampling frequencies cover a very wide span—from daily to once every three years. Almost all of the sampling is performed on a "grab" basis, and the grab samples are either composited for analysis or analyzed separately. One State (Georgia) has indicated use of continuous composite samplers in its water surveillance program.

Analytical Capabilities

Gamma spectroscopy, gross beta counting equipment, and radiochemistry are being employed by the State laboratories. Availability of gamma spectroscopy equipment and low-background beta counters was selected as an index of State program laboratory capabilities.

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[1] Mr. Markarian is Chief, and Messrs. Williams and Ozolins are staff members of the State Surveillance Program, State Assistance Branch, Division of Radiological Health, Public Health Service, Department of Health, Education and Welfare, Washington, D. C.

[2] Milk sampling information is current through August 1964.

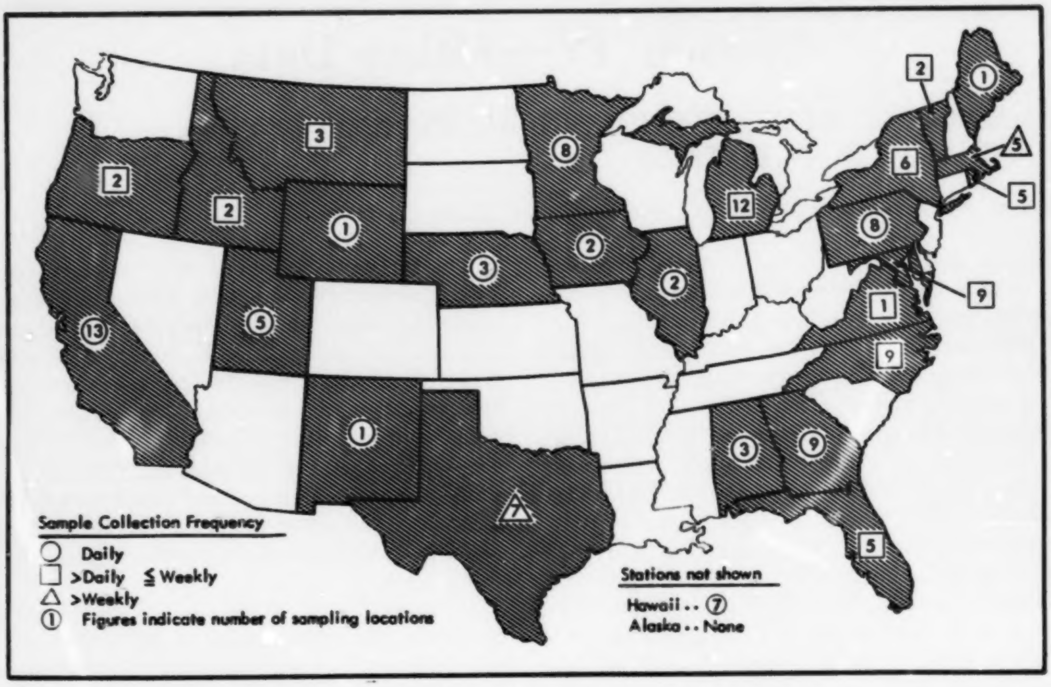
Sample Collection Frequency
○ Daily
☐ >Daily ≦ Weekly
△ >Weekly
① Figures indicate number of sampling locations
Stations not shown
Hawaii .. ⑦
Alaska .. None
2
①
3
⑧
2
2
2
①
12
6
5
5
⑤
③
②
⑧
②
9
1
⑬
⑤
9
①
③
⑨
7
5

FIGURE 1.—AIR SAMPLING STATIONS, JUNE 1963

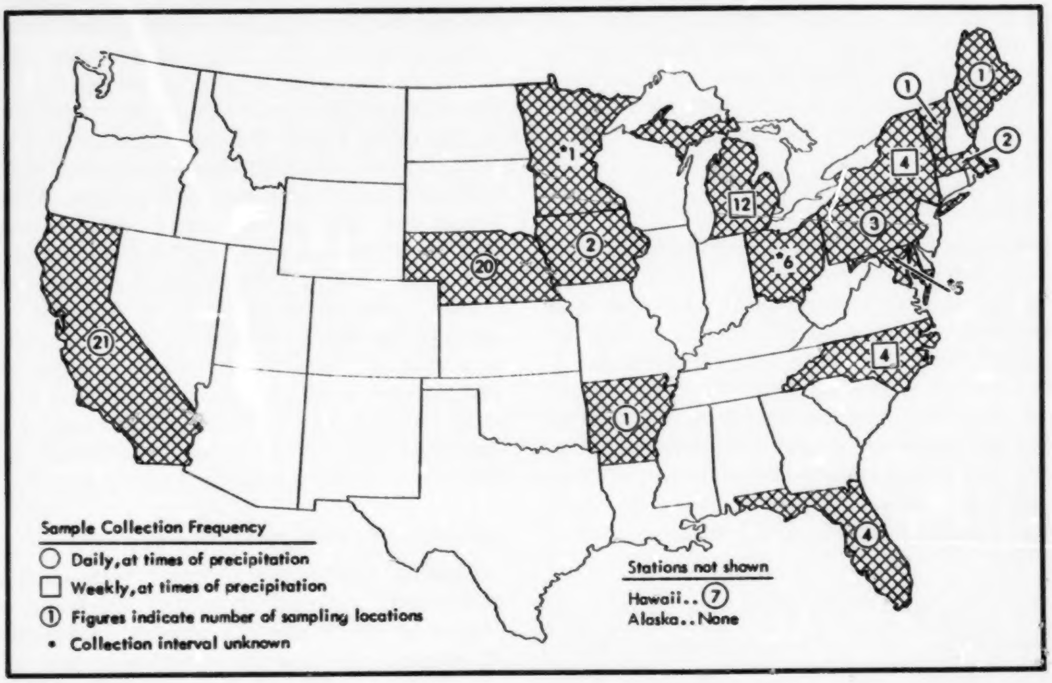
Sample Collection Frequency
○ Daily, at times of precipitation
☐ Weekly, at times of precipitation
① Figures indicate number of sampling locations
• Collection interval unknown
Stations not shown
Hawaii .. ⑦
Alaska .. None
①
①
•1
②
4
12
③
②
⑳
•6
•5
㉑
4
①
④

FIGURE 2.—PRECIPITATION SAMPLING STATIONS, JUNE 1963

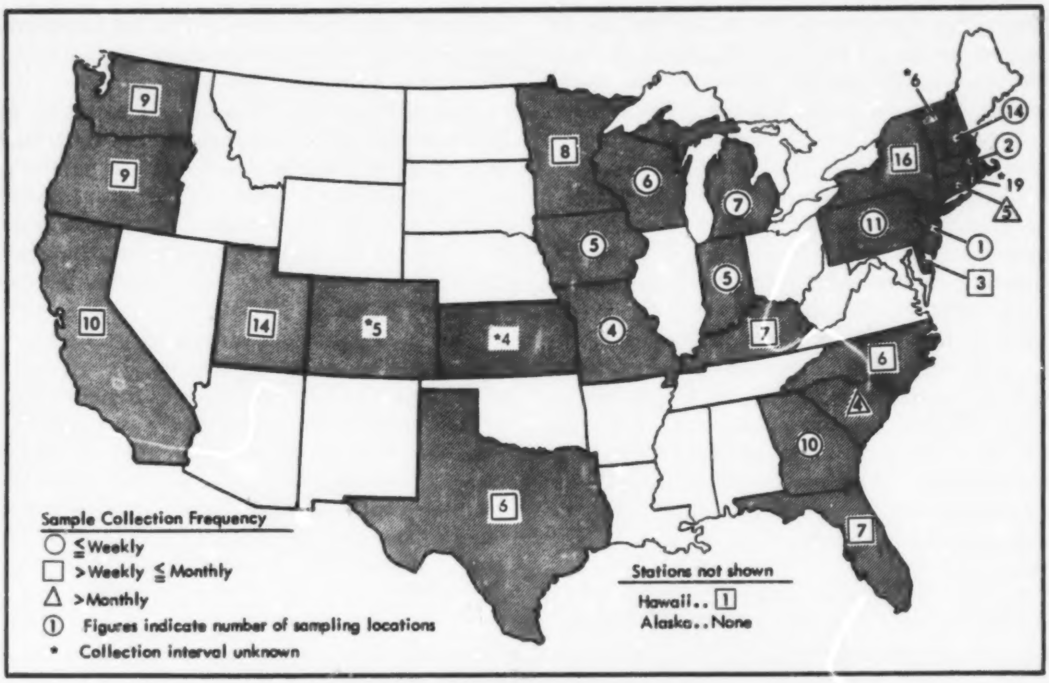
Sample Collection Frequency
○ ≦Weekly
□ >Weekly ≦ Monthly
△ >Monthly
① Figures indicate number of sampling locations
* Collection interval unknown
Stations not shown
Hawaii.. 1
Alaska.. None
9
9
10
14
*5
*4
8
6
5
4
7
5
7
16
11
*6
14
2
*19
5
1
3
6
4
10
6
7

FIGURE 3.—MILK SAMPLING STATIONS, AUGUST 1964

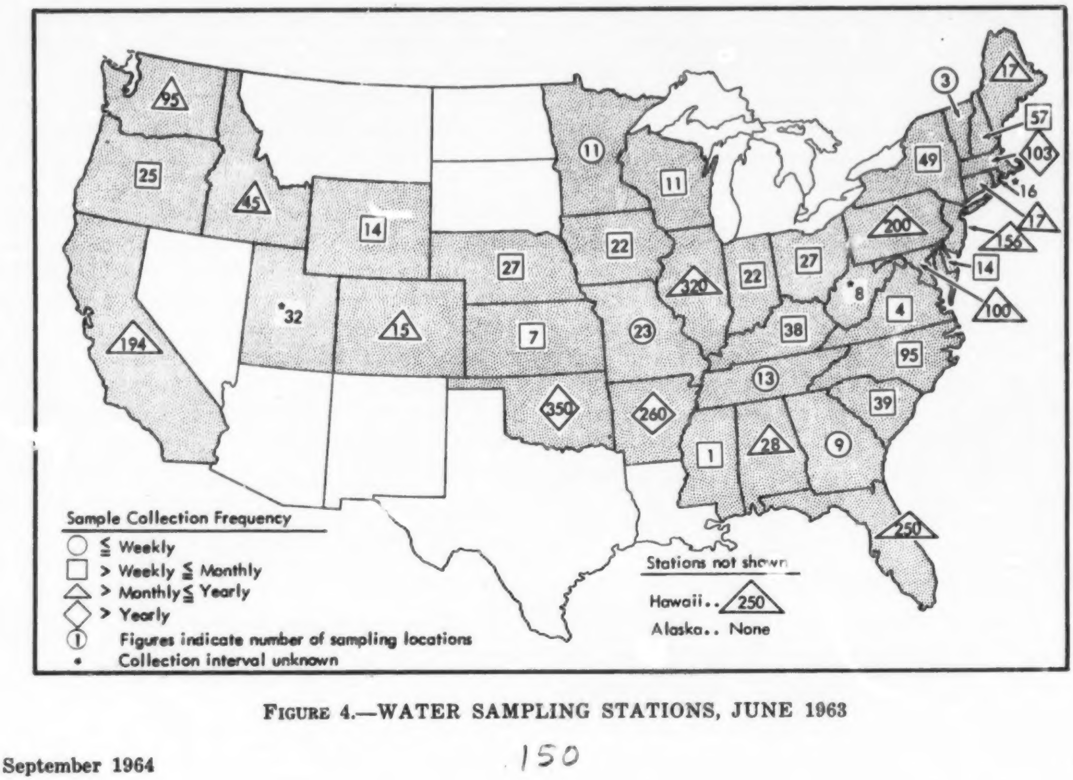
Sample Collection Frequency
○ ≦ Weekly
□ > Weekly ≦ Monthly
△ > Monthly ≦ Yearly
◇ > Yearly
① Figures indicate number of sampling locations
• Collection interval unknown
Stations not shown
Hawaii.. 250
Alaska.. None
95
25
45
194
*32
14
27
15
7
350
260
11
22
23
11
320
22
27
*8
38
4
13
95
39
1
28
9
250
3
17
57
103
49
*16
17
200
156
14
100

FIGURE 4.—WATER SAMPLING STATIONS, JUNE 1963

Gamma spectrometers—single channel, multichannel, or both—are now present in the laboratories of 38 States. (Two of the spectrometers were on order at the time of the status reports.) Nine States have single-channel spectrometers, 15 States have multichannel units and 14 States have both single-channel and multichannel spectrometers.

Twenty-five States have indicated they are equipped with low-background beta counters, and two additional States have these on order. The following 22 States have in their laboratories both the low-background beta counters and gamma spectrometers: California, Connecticut, Florida, Georgia, Hawaii, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Tennessee, Texas, and Washington.

There are differences between States as to type and extent of analyses performed for different environmental radiation vectors; i.e., one State may measure only the gross beta activity on air samples, whereas another State may also perform gross alpha and a gamma scan. Table 1 summarizes the general types of analyses performed by the State laboratories.

The process of instrument calibration includes the selection and acquisition of standards and the application of these for the determination of the efficiencies of the counting equipment. These standards have been available to the State laboratories from agencies of the U. S. Government as well as private industry. During the period from March 1963 to May 31, 1963, 36 States have requested and received over 200 standards for calibration purposes from the Public Health Service. Cesium-137, radium-226, cerium-144, zinc-65, cobalt-60, ruthenium-106 and strontium-90 have been the nuclides requested most frequently during this period. During the early stages of operation, some States have requested and received outside assistance in calibration of gamma spectrometers.

A quality control program is a useful tool in determining and increasing the uniformity and reliability in the results of the participating laboratories. Cross-checking of results may be of great value especially to laboratories in their early stages of operation. The need for such interlaboratory comparisons has been indicated by State laboratories by their desire to participate in quality control studies.

Recognizing the need for obtaining comparable data, 11 State laboratories participated in a quality control program for evaluation of iodine-131 measurements in milk. Milk samples of known iodine-131 content were distributed by the Public Health Service to these laboratories for their measurement of iodine-131 concentration. The quality control studies are being conducted by the Analytical Quality Control Service at the Northeastern Radiological Health Laboratory, Winchester Massachusetts.

Remarks

The status of State environmental surveillance programs is continually undergoing changes dependent upon the prevalence of potential sources of contamination, fluctuations in the levels of radioactivity, availability of personnel and support for initiating or expanding surveillance programs. While earlier surveillance activities emphasized fallout measurements, interest is now expanding to include surveillance activities in the vicinity of nuclear installations such as reactors and processing plants. Another fundamental concern of surveillance programs is that of producing reliable measurements, and this is currently being implemented through further participation in quality control studies.

TABLE 1.—TYPES OF ANALYSES PERFORMED BY STATE LABORATORIES

Environmental media	Number of States participating					
	Sampling programs	Analyses				
		Gross alpha	Gross beta	Gamma scan	Strontium-89	Strontium-90
Air	26	8	26	6	0	0
Precipitation	15	9	15	6	0	0
Milk	27	0	0	22	14	21
Water	41	30	39	8	0	0

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U. S. Atomic Energy Commission receives from its contractors quarterly reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 23 AEC installations have appeared periodically in *RHD* since November 1960. The environmental monitoring summaries for Calendar Year 1963 for the Atomics International facility, National Reactor Testing Station and Pinellas Peninsula Plant are presented below.

Releases of radioactive materials from these plants for the periods covered in the reports below may be compared with standards set forth in the Federal Register, Title 10, Part 20. The appropriate concentration standards are given in table 1. Total alpha data in the Atomics International and National Reactor Test Station reports may be compared with the standards on line 2 in table 1. Total beta acivity may be compared with lines 1 and 3. Additionally the Federal Radiation Council daily intake guides for iodine-131, strontium-89, and strontium-90 are noted.

TABLE 1.—CONCENTRATION STANDARDS [a] PERTAINING TO ENVIRONMENTAL MONITORING AT INSTALLATIONS REFERRED TO IN TEXT

Line No.	Radionuclide or mixture of radionuclides	Air (pc/m³)	Water (pc/liter)
1	If Sr^{90}, I^{129}, Pb^{210}, Po^{210}, Ra^{223}, Ra^{226}, Ra^{228}, and Th-nat are not present [b]	—	2,000
2	Mixtures of unidentified nuclides	0.04	10
3	If α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, Bk^{249} are not present [b]	100	—
4	Hydrogen-3 (tritium)	500,000	3,000,000
5	Iodine-131 [c]	300	2,000
6	Strontium-90 [c]	10	100
7	Cesium-137	500	20,000

[a] The concentration standards given here were taken from the Atomic Energy Commission's regulation 10CFR, Part 20 (Federal Register, November 17, 1960).

[b] "Not present" implies that the concentration of the nuclide is small (<10%) compared with its appropriate MPC. See Federal Register, Title 10, Part 20, August 9, 1961.

[c] Daily intake guides recommended by the Federal Radiation Council (top of range II) are: iodine-131, 100 pc/day; strontium-89, 2000 pc/day; and strontium-90, 200 pc/day.

1. ATOMICS INTERNATIONAL
Calendar Year 1963

Canoga Park, California

Atomics International, a division of North American Aviation, Incorporated, operates the Nuclear Development Field Laboratory (NDFL) and the World Headquarters Facility (WHF) at Canoga Park, California, under contract with the Atomic Energy Commission. The company designs, develops, and constructs nuclear reactors for control stations, compact power plants, and medical, industrial, and scientific applications. Locations of the facilities are shown in figure 1.

The NDFL facilities include a 20-megawatt sodium reactor experiment (SRE) power reactor; several smaller experimental reactor facilities such as critical facilities, Systems for Nuclear Auxiliary Power (SNAP) reactor, shield test facilities, and others; and extensive rolling and fuel fabrication operations. The WHF is primarily an administrative building, but a small amount of fuel fabrication is conducted there. For this reason, the WHF area is included in the environmental monitoring.

Environmental monitoring is conducted at WHF and NDFL to test the effectiveness of radiological safety procedures and of engineering safeguards incorporated into facility design. Surface soil, vegetation, water and air samples are surveyed periodically.

Air Monitoring

Environmental air sampling is conducted continuously at the WHF and NDFL sites with automatic air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on a stationary filter tape which is automatically changed at the end of each sampling period. The filter tape is removed, allowed to decay for 72 hours and counted in an automatic proportional counting system. The volume of a typical daily air sample is approximately 21 cubic meters. The minimum detection limit is on the order of 0.02 pc/m³. Averages for beta-gamma activity in airborne particulates are given in table 2.

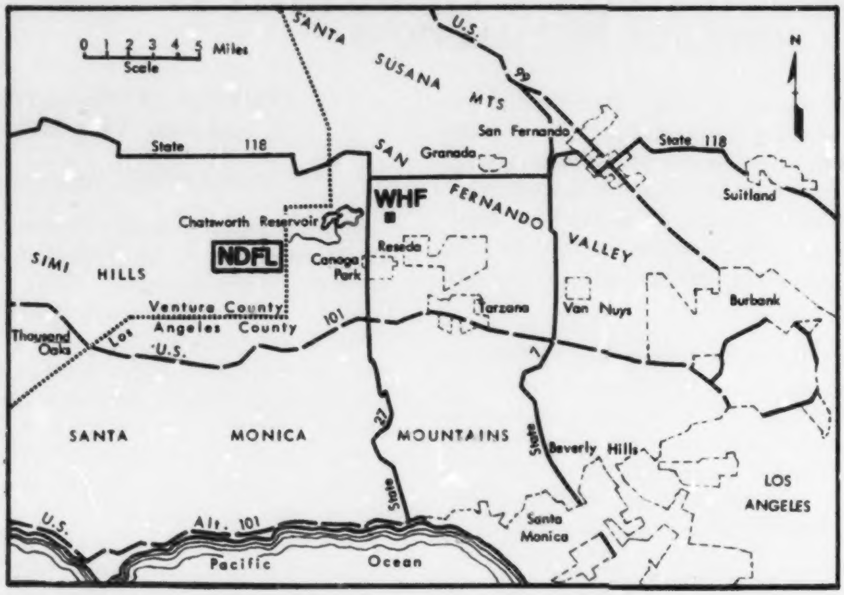
0 1 2 3 4 5 Miles
Scale
N
SANTA SUSANA MTS
U.S. 99
San Fernando
State 118
Granada
SAN FERNANDO VALLEY
Sylmar
Suitland
WHF
Chatsworth Reservoir
NDFL
Canoga Park
Reseda
SIMI HILLS
Van Nuys
Burbank
Tarzana
Ventura County
Los Angeles County
101
Thousand Oaks
U.S.
SANTA MONICA MOUNTAINS
State 27
State 7
Beverly Hills
LOS ANGELES
Santa Monica
U.S.
Alt. 101
Pacific Ocean

FIGURE 1.—ATOMICS INTERNATIONAL FACILITIES AND VICINITY

TABLE 2.—AIRBORNE RADIOACTIVITY DATA—1963 SEMIANNUAL AVERAGE

[β-γ activity in pc/m³]

Site	First half 1963		Second half 1963	
	Number of samples	Average concentration	Number of samples	Average concentration
Headquarters	179	9.6	181	3.7
NDFL	141	6.9	151	2.7

Water Samples

Process water at the NDFL is obtained from wells and stored in 50,000 gallon tanks. Monthly samples are collected from these wells (see table 3). Potable water is obtained in bottles delivered to the site and is, therefore, not analyzed. Process water is drawn from the wells into one liter polyethylene bottles for transfer to the laboratory. Water samples from the lake surface and supply inlet of Chatsworth Reservoir are similarly obtained (see table 4).

TABLE 3.—WELL WATER MONITORING, NDFL, 1963

[pc/liter]

Activity	First half 1963		Second half 1963	
	Number of samples	Average	Number of samples	Average
α	12	[a] 0.23	12	[a] 0.13
β-γ	12	10	12	[a] 4.3

[a] Rounded from range of values originally reported.

TABLE 4.—CHATSWORTH RESERVOIR WATER SAMPLING, 1963

[pc/liter]

Sample	Activity	First half 1963		Second half 1963	
		Number of samples	Average	Number of samples	Average
Lake surface	α	24	0.75	13	1.0
	β-γ	24	19	13	16
Supply inlet	α	6	0.46	6	0.69
	β-γ	6	[a] 10.5	6	7.8

[a] Rounded from range of values originally reported.

In the laboratory, 500 ml. of water are evaporated to dryness in crystallizing dishes at approximately 90° C. The residue salts are transferred into stainless steel planchets, wetted to produce an even sample distribution, redried under infrared lamps, and counted in an automatic proportional counting system.

Soil and Vegetation Samples

Soil and vegetation are sampled monthly at 51 locations. Thirteen sampling stations are located within the boundaries of Atomics International and are designated as on-site stations. The remaining 38 stations are located within a 10-mile radius of Atomics International and are referred to as off-site stations. Several of the off-site stations are located at Chatsworth Reservoir, which is operated by the Los Angeles City Department of Water and Power.

Surface soil samples range from decomposed granite to clay and loam and are collected from the top half-inch layer of ground surface. The samples are placed in plastic containers and sent to the laboratory. Sample preparation consists of drying the soil in a muffle furnace at 500° C. for approximately eight hours, cooling, and sieving to obtain uniform particles for counting. One-gram aliquots of the soil are put in stainless steel planchets, wetted with acetone, redried, and counted in an automatic proportional counting system. Alpha and beta-gamma activities of soil samples are given in table 5.

TABLE 5.—SOIL RADIOACTIVITY, 1963

[pc/g]

Area	Activity	First half 1963		Second half 1963	
		Number of samples	Average	Number of samples	Average
On-site	α	78	[a]0.44	78	[a]0.42
	β-γ	78	44	78	45
Off-site	α	227	[a]0.41	228	[a]0.37
	β-γ	227	41	228	44

[a] Rounded from range of values originally reported.

Vegetation samples obtained in the field at each station are generally sunflower or wild tobacco plant leaves. At the laboratory the leaves are stripped from the plant and washed to remove foreign matter. The vegetation, after a distilled water rinse, is ashed in a muffle furnace at 500° C. for approximately eight hours, thus producing a completely oxidized ash of uniform density. Three-hundred milligram aliquots of ground ash are used for counting in an automatic proportional counting system. Vegetation data are shown in table 6.

TABLE 6.—RADIOACTIVITY IN VEGETATION, 1963

[pc/gm ash]

Area	Activity	First half 1963		Second half 1963	
		Number of samples	Average	Number of samples	Average
On-site	α	78	[a]0.52	78	[a]0.36
	β-γ	78	558	78	373
Off-site	α	228	[a]0.45	228	[a]0.29
	β-γ	228	489	228	287

[a] Rounded from range of values originally reported.

Previous coverage in *Radiological Health Data:*

Period	Issue
1960 and first and second quarters 1961	*December 1961*
Third and fourth quarters 1961	*August 1962*
Calendar year 1962	*November 1963*

2. NATIONAL REACTOR TESTING STATION

Calendar Year 1963

Health and Safety Division
Atomic Energy Commission
Idaho Falls, Idaho

The National Reactor Testing Station (NRTS) is located in a very remote area which, in a large measure, permits controlled releases of radioactivity from the projects with minimum risk to the environs.

Responsibility for holding the environmental radioactivity levels at the station below the Radiation Protection Guides (RPG) recommended by the Federal Radiation Council (FRC) lies with the Atomic Energy Commission. One of the safeguards employed is a monitoring program. Descriptions of the monitoring network procedures have been presented earlier (see previous coverage). Quarterly environmental monitoring results, in addition to calendar year averages for 1963, are shown in table 7. Sampling locations at NRTS can be seen in figure 2.

TABLE 7.—ENVIRONMENTAL MONITORING PROGRAM DATA, NRTS, 1963

Type of sample and units	No. of stations	Approximate frequency of collection	Type of analysis	Minimum level of detection	1963 Quarterly averages				1963 Calendar year summary
					First quarter	Second quarter	Third quarter	Fourth quarter	
Off-site underground water (pc/liter)	32	Three months	α β H^3	3 6 4000	<4 <20 <4000	<3 <30 <4000	<4 <40 <4000	<4 <20 <4000	<4 <30 <4000
On-site production well water (pc/liter)	22	Two weeks	α β H^3	3 6 4000	4 20 <7000	<4 <20 <7000	<3 <20 <8000	<4 <20 <8000	<4 <20 <7000
Off-site air filters (pc/m³)	14	weekly	β	(not given)	20	23	12	5	15
Off-site milk (pc/liter)	13 10	monthly monthly [b]	I^{131} Sr^{90}	[a] 20 1.5	12 10	<10 36	<20 30	<20 23	<20 25
Off-site area monitoring badges (mrem)	14	monthly [c]	α β	10 10	<30 <30	<40 <30	<30 <30	<30 <30	<140 <120

[a] Changed from 10 to 20 in August of 1963.
[b] Changed from 2 months to monthly in 1963.
[c] Changed from 6 weeks to monthly in 1963.

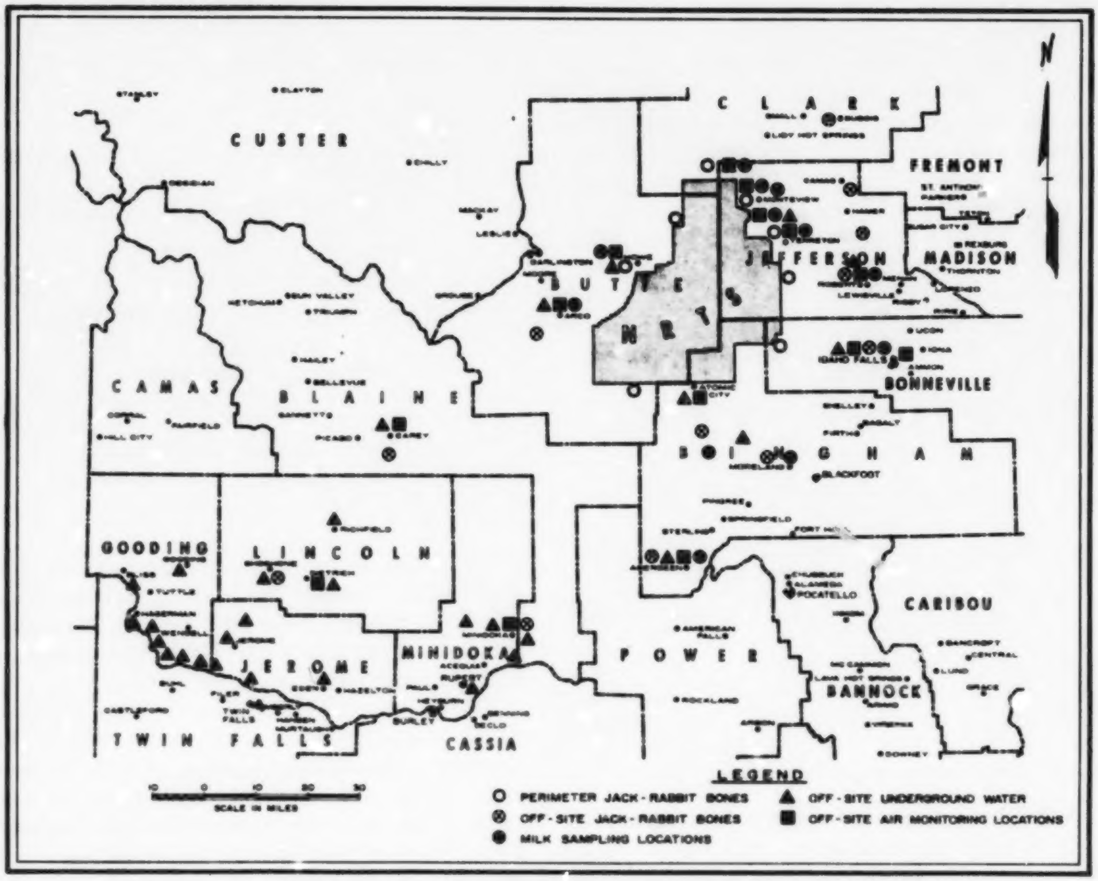
N
CUSTER
CLARK
FREMONT
JEFFERSON
MADISON
BUTTE
NRTS
CAMAS
BLAINE
BONNEVILLE
BINGHAM
GOODING
LINCOLN
JEROME
MINIDOKA
POWER
CARIBOU
BANNOCK
TWIN FALLS
CASSIA
IDAHO FALLS
ATOMIC CITY
BLACKFOOT
POCATELLO
ARCO
CAREY
RICHFIELD
RUPERT
BURLEY
ROCKLAND
DOWNEY
10 0 10 20 30
SCALE IN MILES
LEGEND
○ PERIMETER JACK-RABBIT BONES
⊗ OFF-SITE JACK-RABBIT BONES
● MILK SAMPLING LOCATIONS
▲ OFF-SITE UNDERGROUND WATER
■ OFF-SITE AIR MONITORING LOCATIONS

FIGURE 2.—ENVIRONMENTAL MONITORING STATIONS, NATIONAL REACTOR TESTING STATION

Previous coverage in *Radiological Health Data:*

Period	Issue
1959 and first quarter 1960	*December 1960*
Second quarter 1960	*February 1961*
Third and fourth quarters 1960	*May 1961*
First and second quarters 1961	*January 1962*
Third and fourth quarters and calendar year 1961	*June 1962*
Calendar year 1962	*June 1963*

3. PINELLAS PENINSULA PLANT
Calendar Year 1963

General Electric Company
St. Petersburg, Florida

Pinellas Peninsula Plant shown in figure 3, is an electronic component production facility in the Atomic Energy Commission's Albuquerque Operations Office manufacturing complex. Environmental monitoring includes sampling of a single combined sewer effluent, milk from five local dairy farms, air, and surface water obtained at locations suggested by meterological conditions and radioactivity discharge concentrations. Except for air samples which may contain tritium gas, the radioactive portion of the samples is essentially tritium oxide.

Air Monitoring

Air samples are obtained periodically in areas up to 2 miles downwind from the exhaust stack, where maximum ground level concentrations would be expected. During the entire year, air sample analyses revealed no detectable concentrations of tritium gas (<1,300,000 pc/m^3 of air)* or tritium oxide (<5,000 pc/m^3 of air).

Water Sampling

A combined sewer effluent sample is obtained daily from beyond the perimeter of the plant's property. During the year, there were no detectable concentrations of tritium oxide (<120,000 pc/liter) in the 244 samples taken.

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* Expressions in parentheses indicate limits of detectability in the respective environmental samples.

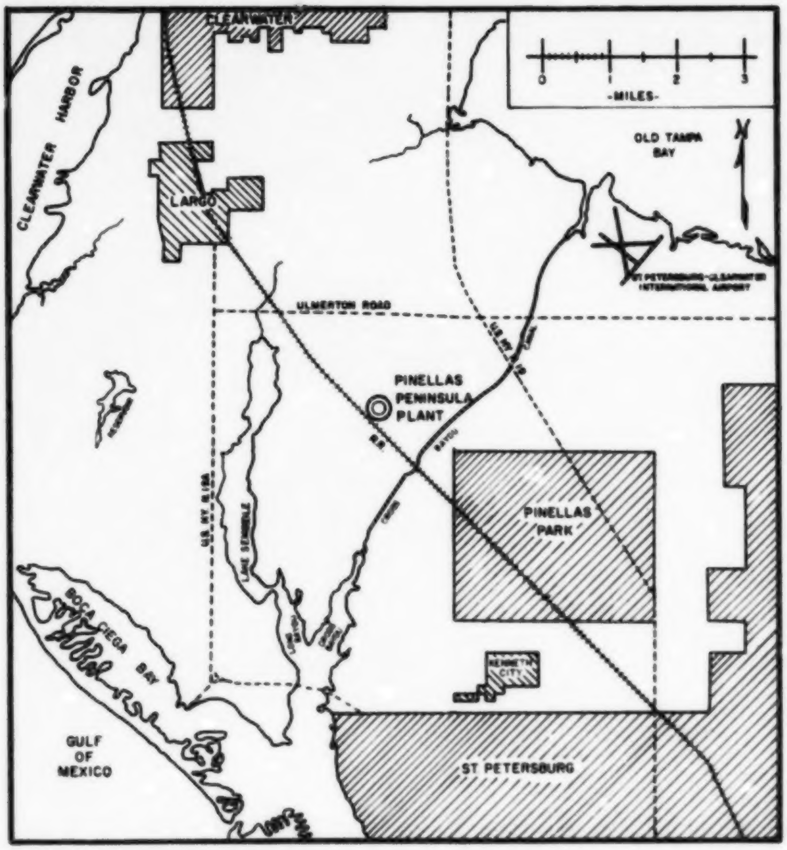
CLEARWATER
CLEARWATER HARBOR
LARGO
0
1
2
3
-MILES-
OLD TAMPA BAY
ST PETERSBURG-CLEARWATER INTERNATIONAL AIRPORT
ULMERTON ROAD
U.S. HY 19
PINELLAS PENINSULA PLANT
R.R.
BAYOU
U.S. HY 19A
LAKE SEMINOLE
PINELLAS PARK
BOCA CIEGA BAY
KENNETH CITY
GULF OF MEXICO
ST PETERSBURG

FIGURE 3.—LOCATION OF THE PINELLAS PENINSULA PLANT SITE

Surface water samples are normally obtained during the last week in each month at locations within 6 miles of the plant. These points are determined by radioactivity discharges in the exhaust stack effluent and meteorological data. In the event of accidental discharge of significant amounts of tritium, samples are obtained at the point of maximum ground deposition during or immediately following such discharges. There were no indications of tritium in 100 surface water samples analyzed during the year.

Milk Sampling Results

Forty-four samples of raw milk were taken from farms within a 3-mile radius of the plant. These samples were analyzed by the Florida State Board of Health during 1963. No detectable concentrations (<120,000 pc/liter) of tritium oxide were evident.

Previous coverage in *Radiological Health Data:*

Period	Issue
1960–1961	*July 1962*
Calendar year 1962	*June 1963*

REPORTED NUCLEAR DETONATIONS, AUGUST 1964

During August 1964 three underground nuclear tests at the Nevada Test Site were announced by the Atomic Energy Commission. Tests conducted on the 19th, 22nd, and 28th of the month were of low, low intermediate, and low yields, respectively, and were assigned *RHD* reference numbers 163–165 in chronological order. (Low yield is defined as equivalent to less than 20 kilotons of TNT; low intermediate yield is equivalent to from 20 to 200 kilotons of TNT.)

157